D.B.F. Dayanand College of Arts and Science, Solapur

Department of Physics

COURSE OUTCOME

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	**I** / ~~II / III / IV~~
COURSE NUMBER (PAPERNUMBER)	**HCT 1.1**
TITLE OF COURSE (NAME OF PAPER)	**Mathematical Physics**

COURSE OBJECTIVE: The purpose of the course is to introduce students the concepts of mathematical physics and to enhancedesired mathematical skills and abilities to solve problems in quantum mechanics, electrodynamics and other fields of physics.

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Calculus of Residues Complex Variable And Representations: 1.1 Algebraic Operations 1.2 Argand Diagram: Vector Representation, Complex Conjugate 1.3 Euler's Formula 1.4 De Moiver's Theorem 1.5 The n^{th} Root or Power of a complex number. Analytical Functions Of A Complex Variable: 1.6 The Derivative of f(Z) and Analyticity, 1.7 Harmonic Functions 1.8 Contour Integrals 1.9 Cauchy's Integral Theorem- Cauchy's Integral Formula,Zeros, Isolated Singular points, Evaluation of Residues 1.10 Cauchy's Residue theorem.	• The student should be able to understand basic concepts of vector, tensor analysis and functions of complex variables	• Students can understand to apply methods of functions of complex variables for calculations of integrals • They can work with vectors
Unit II : Operator and Matrix Analysis 2.1 Vector Space and its dimensionality 2.2 Vector Spaces and Matrices 2.3 Linear independence- Bases; Dimensionality 2.4 Linear dependence- Inner product Hilbert space, linear operators 2.5 Matrix operations	• The student will learn about special type of matrices that are relevant in physics	• Understand the linear equations, vector spaces, matrices, linear transformations, determinants, eigenvalue, eigenvectors, etc.

2.6 properties of matrices 2.7 Inverse, Orthogonal and unitary matrices 2.8 Independent elements of a matrix 2.9 Diaglonization- Complete orthogonal sets of functions, special square matrices, 2.10 Eigen values and eigenvectors; Eigen value problem.		
Unit III: Ordinary Differential Equations 3.1 First-Order homogeneous and non homogeneous equations with variable coefficients. 3.2 The superposition principle 3.3 Second-order homogeneous equations with constant coefficient 3.4 Second- order non homogeneous equations with constant coefficients.	• To learn different ways of solving first and second order differential equations	• Use different methods for second order differential equations with constant coefficients.
Unit IV: Fourier Series, Integral Transforms and Laplace transform Fourier Series: 4.1 Fourier’s theorem; Cosine, Sine and complex Fourier series, 4.2 Applications to saw tooth and square waves and full wave rectifier 4.3 FS of arbitrary period 4.4 Half wave expansions 4.5 Partial sums Fourier integral and transforms 4.6 cosine since complex forms 4.7 Parsevals relation 4.8 Application to Gaussian distribution, box and exponential functions 4.9 FT of delta function. Laplace transforms: 4.10 Laplace transforms of common functions, 4.11 First and second shifting theorems 4.12 Inverse LT by partial fractions 4.13 LT of derivative and integral of a function.	• The student will learn the basics and applications of Fourier series, Fourier and Laplace transforms, their inverse transforms etc	• Introduce the Fourier series and its application to the solution of partial differential equations • Learn to use Laplace transform methods to solve differential equations

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	**I** / ~~II / III / IV~~
COURSE NUMBER (PAPERNUMBER)	**HCT 1.2**
TITLE OF COURSE (NAME OF PAPER)	**Solid State Physics**

COURSE OBJECTIVE: The course gives an introduction to solid state physics, and will enable the student to apply classical and quantum mechanical theories to understand the physical properties of solids.

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Crystal Structure Basic Structures, Bravais systems in 2D and 3D, Bonding in solids, Reciprocal Lattice, Diffraction by X-ray and structure factor, Point defects and dislocations, Specific Heat: Lattice vibration, Phonons, Einstein and Debye's theories.	• This unit enable the students to understand about the crystal structure, interaction with X-ray, lattice vibrations and defects.	• The student is expected tohave a basic knowledge of crystal systems and be able to account for how crystalline materials are studied using diffraction, including concepts like reciprocal lattice and Brillouin zones
Unit II: Energy bands and Semiconductors Energy bands:Metal, Insulator and Semiconductor, Bloch theorem, Electron in periodic potential -1D, Tight and loose band approach, Brillion's Zones, Fermi surfaces. Semiconductors:Direct and indirect band gap semiconductors, Effective mass, Hall effects and thermoelectric power, Intrinsic and Extrinsic carrier concentration.	• To study Bloch theorem and what energy bands are. • To know the fundamental concepts of semiconductors	• Student is able to calculate thermoelectrical properties in the free-electron model
Unit III: Dielectrics Electronic, Ionic, Orientational polarizations, Clausius-Mossotti equation, Dipole theory of ferroelectricity, Internal field in solids, Classification of magnetic materials.	• To know the fundamentals of dielectric and ferroelectric propertiesof materials.	• The student is expected toknow basic models of dia, para and ferro magnetism

Unit IV: Superconductors Basic concept, Meissner effect, Types I and II, Thermal properties of superconductor, Thermodynamics of superconductors, London equation, Josephson tunneling and its theory, BCS theory.	• To study fundamentals of superconductivity.	• Learn to explain superconductivity using BCS theory

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	**I** / ~~II / III / IV~~
COURSE NUMBER (PAPERNUMBER)	**HCT 1.3**
TITLE OF COURSE (NAME OF PAPER)	**Analog & Digital Electronics**

COURSE OBJECTIVE: The course has been designed to introduce fundamental principles of analog and digital electronics commonly used in applied electronics research.

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Operational Amplifiers 1.1 Differential amplifier Circuit Configurations, 1.2 Dual Input Balanced Output Differential amplifier 1.3 DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circuit. 1.4 Block diagram of a typical Op-Amp 1.5 Open loop configuration 1.6 Inverting and Non- inverting amplifiers, 1.7 Op-amp with negative feedback, Voltage Series Feedback 1.8 Effect of feedback on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower. 1.9 Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.	• To learn basic operational amplifier characteristics, Op-Ampparameters ,applications as inverter, integrator, differentiator,etc • To study effect of feedback on gain	• Students understood the operations of different applications of op-amp. • Learned to distinguish between analog and digital systems.
Unit II: Applications of Op amps 2.1 DC and AC amplifier- Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator. 2.2 Oscillator: Principles, Oscillator types, Frequency stability, Response 2.3 Phase Shift oscillator 2.4 Wein Bridge Oscillator 2.5 LC Tunable Oscillator 2.6 Multivibrators- Monostable and Astable, Comparators	• To understand DC analysis and AC models of semiconductor devices. • To verify the theoretical concepts through laboratory and simulation experiments.	• Analyze dc circuits and relate ac models of semiconductor devices with their physical Operation

Unit III: Combinational & Sequential Logic Circuits Combinational logic: 3.1 The transistor as a switch 3.2 OR AND NOT gates- NOR And NAND gates 3.3 Boolean algebra- Demorgans theorems, Multiplexers and Demultiplexers Sequential Logic: 3.4 Flip- Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flop, D Flip- Flop, Shift registers 3.5 Synchronous and Asynchronous counters.	• To provide the information about the electronic components diode, transistor. • Toenhance the knowledge of IC fabrication.	• Learned and understood the basics of digital electronics, Boolean algebra, and able to design the simple logic circuits and test/verify the functionality of the logic circuits
Unit IV: Microprocessors 4.1 Architecture of 8085 4.2 Signals and timing diagram of 8085 4.3 Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly 4.4 Language Programming of 8085 (Sum /Subtraction, Multiplication & Division of 4 & 8 bit numbers) .	• To study the organization and internal architecture of the 8085	• Able to write assembly language program for microprocessors. • Able to draw and describe architecture of 8085

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	**I** / ~~II / III / IV~~
COURSE NUMBER (PAPERNUMBER)	**SCT 1.1**
TITLE OF COURSE (NAME OF PAPER)	**Classical Mechanics**

COURSE OBJECTIVE: To improve knowledge and understanding of the concepts: the dynamics of system of particles, motion of rigid body and Lagrangian and Hamiltonian formulation of mechanics

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I : Mechanics of Particles and Rigid Bodies 1.1 Mechanics of Particle 1.2 System of Particles using vector algebra and vector calculus 1.3 Conservation laws- work-energy theorem, open systems (with variable mass), 1.4 Gyroscopic forces- dissipative systems, 1.5 Jacobi integral- gauge invariance, integrals of motion 1.6 Symmetries of space and time with conservation laws; invariance under Galilean transformations.	• Introduction to classical mechanics • To make students more familiar with conservation laws • To get knowledge of different transformations • To get detailed idea of symmetries between space and time	• Students understood how to use vector algebra to describe the motion • Students learned different conservation laws
Unit II: Lagrangian Formulation and Motion Under Central Force 2.1 Constrainsts 2.2 Generalised co-ordinates, 2.3 D'Alemabert's Principle, 2.4 Lagrange's equations of motion 2.5 Central Force- definition and characteristics, 2.6 Reduction of Two-body problem into equivalent One-body problem, 2.7 General analysis of orbits 2.8 Kepler's laws and equations 2.9 Artificial satellites 2.10 Rutherford Scattering.	• To know existence of other formalism like Lagrangian to write equations of motion • To understand differential equation of orbit and learn how to solve numericals on it	• Students found Lagrangian formulation more convinient than Newtonian formulation

Unit III: Variational Principle 3.1 Introduction to Calculus of variation 3.2 Variational technique for many independent variables 3.3 Eulers Lagrange differential equation, Hamilton's principle 3.4 Deduction of Lagrange's equation of motion from Hamilton's principle. 3.5 Hamiltonian- Generalized momentum, Constant of motion 3.6 Hamilton's canonical equations of motion, 3.7 Deduction of canonical equations from Variational principle 3.8 Applications of Hamilton's equations of motion 3.9 Principle of least action- Proof of principles of least action 3.10 Problems.	• Introduction to Calculus of variation • To know about Hamiltonian formulation • To understand all the three formulations are related • To give hand on experience to solve numerical problems	• Students understood knowledge of energies is sufficient to describe motion • Also understand results of Lagrangian and Hamiltonian formulation are invariant
Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory 4.1 Canonical Transformations 4.2 Condition for Transformation to be Canonical 4.3 Illustration of Canonical Transformation 4.4 Poisson's Brackets- Properties of Poisson's Brackets, 4.5 Hamilton's Canonical equations in terms of Poisson's Brackets 4.6 Hamilton's - Jacobi Theory 4.7 Solution of harmonic oscillator problems by HJ Method, Problems.	• To give introduction to transformation between coordinate systems • To know Poisson's brackets and their properties	• Students found transformations cantaffect on solutions of problem • HJ can be incorporated to solve the mechanics problems

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**	
NAMEOFSUBJECT	**Physics**	
SPECIALIZATION	**Solid State**	
SEM	~~I~~ / **II** / ~~III / IV~~	
COURSE NUMBER (PAPERNUMBER)	**HCT 2.1**	
TITLE OF COURSE (NAME OF PAPER)	**Quantum Mechanics**	
COURSE OBJECTIVE:This course has been designed to identify and understand the kinds of experimental results which are incompatible with classical physics and which required the development of a quantum theory of matter and light.		
COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Introductory Quantum mechanics 1.1 Waves and quanta 1.2 Wave and particle nature of radiation, 1.3 Wave equation 1.4 Interpretation and properties of wave function 1.5 Heisenberg uncertainty principle 1.6 Operators 1.7 Postulates of quantum mechanics 1.8 Some important theorems 1.9 Eigen functions of the position operator and Dirac delta function.	• To study the basic principles of quantum mechanics. • It explains the operator formulation of quantum mechanics. • Student will learn the concept of wave function • To study role of uncertainty in quantum physics.	• Understand the idea of wave function • Understand the uncertainty relations. • Understand and explain the differences between classical and quantum mechanics
Unit II:Wave Mechanics of simple systems 2.1 One dimensional Box 2.2 Normalization and orthogonality 2.3 Discussion of the factors influencing colour 2.4 One dimensional harmonic oscillator 2.5 Normalization and Characteristics of eigen functions of harmonic oscillator 2.6 Hydrogen - like atoms 2.7 Total wave function of hydrogen- like atom, Prob. Density of 1s atomic orbital, shape of atomic orbital 2.8 physical interpretation of hydrogenic orbital 2.9 space quantization, electronic spin, 2.10Vibration and vibrational spectra of diatomic molecules.	• To learn the wavemechanics and its application to ground state of the hydrogen and hydrogen like atom.	• Able to solve the hydrogen atom problem by using quantum mechanics.

Unit III : Many electron atoms 3.1 Wave function of many electron systems 3.2 Helium atom 3.3 Many electron atoms 3.4 Hartree and HartreeFockself consistent field methods.	• Student learn the concept of wave function of many electron systems	• Student learnt to write the wave function of many electron systems
Unit IV: Molecular Orbitals 4.1 The Born- Oppenheimer approximation 4.2 Molecular orbital theory 4.3 Hydrogen molecule ion 4.4 Hydrogen Molecule - Molecular Orbital - Valance Band methods.	• It will let students appreciate the quantum mechanics in the form of the Born approximation and its validity.	Student able to evaluate the verification of the Born approximation and its validity

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	~~I~~ / **II** / ~~III / IV~~
COURSE NUMBER (PAPERNUMBER)	**HCT 2.2**
TITLE OF COURSE (NAME OF PAPER)	**Electrodynamics**

COURSE OBJECTIVE: To master the method ofevaluating and deriving formulae for the electromagneticfields from very general charge and current distributions. Calculate the electromagnetic radiation from radiating systems.

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Multipole expansions and time varying fields 1.1 Multipole expansions for a localized charge distribution in free space 1.2 Linear quadrupole potential and field, 1.3 Static electric and magnetic fields in material media 1.4 Boundary conditions 1.5 Time dependent fields Faraday's law for stationary and moving media 1.6 Maxwell's displacement current, 1.7 Differential and integral forms of Maxwell's equations 1.8 Maxwell's equations for moving medium.	• To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications • To impart knowledge on the concepts of Faraday's law, induced emf and Maxwell's equations.	• Understand the basic mathematical concepts related to electromagnetic vector fields. • Understand the concepts related to Faraday's law, induced emf and Maxwell's equations.
Unit II: Energy, force, momentum relations and electromagnetic wave equations 2.1 Energy relations in quasi-stationary current systems 2.2 Magnetic interaction between two current loops 2.3 Energy stored in electric and magnetic fields 2.4 Poynting's theorem 2.5 General expression for electromagnetic energy 2.6 Electromagnetic wave equations 2.7 Electromagnetic plane waves in stationary medium 2.8 Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence) 2.9 Electromagnetic waves in conducting medium	• To introduce the basic mathematical methods related to electromagnetic vector fields • To give knowledge on the concepts of electromagnetic waves	• Apply the principles of magneto statics to the solutions of problems relating to magnetic field and magnetic potential, boundary conditions and magnetic energy density.

2.10 Skin effect and skin depth		
Unit III: Inhomogeneous wave equations 3.1 Inhomogeneous wave equations 3.2 Lorentz's and Coulomb's gauges 3.3 Gauge transformations 3.4 Wave equations in terms of electromagnetic potentials 3.5 D'Alembertian operator 3.6 Hertz potential and its use in computation of radiation fields.	• To apprise the students regarding the concepts of electrodynamics and Maxwell equations and use them to various situations	• Apply the laws of electrostatics to the solutions of problems relating to electric field and electric potential, boundary conditions and electric energy density through different gauges. • Formulate and solve EMnumericals with the help of electrodynamic potentials, and make a detailed account for gauge transformations and their use.
Unit IV: Radiation emission 4.1 Radiation from an oscillating electric dipole 4.2 Radiation from a half wave antenna 4.3 Radiation from a group of moving charges 4.4 Radiation damping 4.5 Thomson cross-section.	• To give knowledge on the concepts of electromagnetic radiations	• Understand the basic concepts related to radiation emissions • To calculate the electromagnetic radiation from localised charges which move arbitrarily in time and space, taking into account retardation effects. Account for the underlying approximations and assumptions

Signature of HOD

COURSE	~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**
NAMEOFSUBJECT	**Physics**
SPECIALIZATION	**Solid State**
SEM	~~I~~ / **II** / ~~III / IV~~
COURSE NUMBER (PAPERNUMBER)	**SCT 2.1**
TITLE OF COURSE (NAME OF PAPER)	**Statistical Physics**

COURSE OBJECTIVE: This course explains statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics.

COURSE CONTENT	OBJECTIVES	OUTCOME
Unit I: Statistical Thermodynamics: Thermodynamic systems and equilibria, Laws of thermodynamics and their consequences, Nernst heat theorem, Microstates and microstates, Postulate of equal priori probability, Probability calculations, Thermodynamic potentials and Maxwell's relations, Chemical potential, phase equilibria, Black Body radiation and planks distribution, Phase equilibria, Free energy and its connection with thermodynamic quantities, entropy of mixing and Gibbs and paradox.	• To acquire knowledge of the zeroth and first law of thermodynamics • To apply the laws of thermodynamics	• Student identifies the relationship and correct usage of infinitesinal work, work, energy, heat capacity, specific heat, latent heat, and enthalpy.
Unit II: Classical statistical mechanics: Statistical ensembles, Microcanonical ensemble- system in contact with heat revisor, Condition for thermal equilibrium, canonical ensemble – molecular ideal gas and grand canonical ensemble, Liouville's theorem, Ensembles, Maxwell Boltzmann distribution, classical ideal gas	• To link thermodynamics to the micro description used in classical Statistical Mechanics.	• Student can compute entropy by counting the number of allowed states for simple systems such as the ideal gas (Sakur-Tetrode equation).
Unit III: Quantum Statistical Mechanics Phase space (Diagram of an oscillator), Maxwell- Boltzmann statistics, Fermi-Dirac statistics and Bose- Einstein statistics, Liouville's theorem, Ideal Bose gas, Ideal Fermi gas- weekly and strongly degerate , Bose- Einstein condensation.	• To introduce advanced concepts related to Quantum Statistical Mechanics.	• Student uses either Fermi-Dirac or Bose-Einstein statistics with the knowledge of the spin of the particles.

Unit IV: Phase transitions and critical phenomena Phase transition, Triple Point, Condition for phase equilibrium, First order phase transition, Ehrenfests equations, Clausius- Clayperon equation, Second latent heat equation, Examples, Second order phase transition, Critical indices, The law of corresponding states.	• To impart knowledge of phase transitions and how these transitions are distinguished	• Student recognizes the difference between temperature and heat

Signature of HOD

<table>
<tr><td>COURSE</td><td colspan="2">~~B.A.~~ / ~~B.Sc.~~ / ~~M.A.~~ / **M.Sc.**</td></tr>
<tr><td>NAMEOFSUBJECT</td><td colspan="2">**Physics**</td></tr>
<tr><td>SPECIALIZATION</td><td colspan="2">**Solid State**</td></tr>
<tr><td>SEM</td><td colspan="2">~~I~~ / **II** / ~~III / IV~~</td></tr>
<tr><td>COURSE NUMBER (PAPERNUMBER)</td><td colspan="2">**OET 2.2**</td></tr>
<tr><td>TITLE OF COURSE (NAME OF PAPER)</td><td colspan="2">**Conventional & Nonconventional Energy**</td></tr>
<tr><td colspan="3">COURSE OBJECTIVE: This course has been developed to understand the sources of energy and their contributions to the energy and power needs of the nation and the world.</td></tr>
<tr><td>COURSE CONTENT</td><td>OBJECTIVES</td><td>OUTCOME</td></tr>
<tr><td>**Unit I: Energy Science and Energy Technology**
1.1 A brief history of energy technology
1.2 Various sciences and energy science
1.3 Energy, man and environment
1.4 Thermodynamics and energy analysis1.5 Classification of conventional and non conventional energy sources, Global energy trends
1.6 Hydro energy-merits and demerits
1.7 Primary hydro energy resources
1.8 Types of hydroelectric plants
1.9 Energy and power equations
1.10 Hydraulic turbines
1.11 Fossil Fuels
1.12 Conversion and applications
1.13 Types of coal
1.14 properties of coal
1.15 Coal production and processing.</td><td>• It will enable to understand various conventional and non-conventional energy resources.</td><td>• Understood the working principle of different resources of energy</td></tr>
<tr><td>**Unit II: Solar Energy**
2.1 The solar spectrum
2.2 Semiconductors- p-n junction
2.3 Solar photocells
2.4 Efficiency of solar cells
2.5 Commercial solar cells
2.6 Developing technologies
2.7 Solar panels
2.8 Economics of photovoltaics (PV)
2.9 Environmental impact of photovoltaics2.10 Outlook for photovoltaics,
2.11 Solar thermal power plants
2.12 Solar thermal collectors- Flat plate collectors, Parabolic collectors, paraboloidal dish collector.</td><td>• To make students understand the fundamental theory governing the photovoltaic device.</td><td>• Able to predict the performance of solar photovoltaic device and analyze its performance</td></tr>
</table>

Unit III: Wind and Biomass Energy 3.1 Source of wind energy 3.2 Global wind patterns 3.3 Modern wind turbines 3.4 Kinetic energy of wind 3.5 Principles of a horizontal-axis wind turbine 3.6 Wind turbine blade design 3.7 Dependence of the power coefficient Cp on the tip-speed ratioλ 3.8 Design of a modern horizontal-axis wind turbine 3.9 Turbine control and operation 3.10 Wind characteristics 3.11 Power output of a wind turbine 3.12 Wind farms 3.13 Environmental impact and public acceptance, Economics of wind power, Outlook, Conclusion, 3.14 Photosynthesis and crop yields 3.15 Biomass potential and use 3.16 Biomass energy production 3.17 Environmental impact of biomass 3.18 Economics and potential of biomass Outlook, Biogas plants 3.19 Types of Biogas plants	• It will provide an understanding of the processes for converting biomass to fuels by various approaches. • It develops potential to evaluate technical and economical feasibility & sustainability of energy production from biomass.	• The students will be able to assess the biomass resource, appropriate conversion technology for the given biomass resource & end use. • Identify potential solution to supply limitation & environmental issues related with biomass waste energy resources.
Unit IV: Nuclear Energy 4.1 Binding energy and stability of nuclei 4.2 Fission 4.3 Thermal reactors-Thermal reactor designs, Fast reactors, Present-day nuclear reactors 4.4 Safety of nuclear power: Economics of nuclear power, Environmental impact of nuclear power, Public opinion on nuclear power, Outlook for nuclear power 4.5 Magnetic confinement 4.6 D-T fusion reactor 4.7 Performance of tokamaks, Plasmas 4.8 Charged particle motion in E and B fields 4.9 Tokamaks, Plasma confinement, Divertor tokamaks 4.10 Outlook for controlled fusion	• To learn the role of nuclear energy in future and expectation to advanced reactors	• Studied the nuclear energy is the future of thrust of energy need.

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. III**		
Course No (Paper Code) : **HCT- 3.1**		
Title of Course (Name of Paper) : **Semiconductor Physics**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1. Energy bands and charge carriers in semiconductors 1.1 Bonding forces and energy bands 1.2 Direct and indirect band gap semiconductors 1.3 Variation of energy bands with alloy composition 1.4 Effective mass 1.5 Electrons and holes in quantum wells 1.6 The Fermi level 1.7 Electron and hole concentrations at equilibrium 1.8 Temperature dependence of carrier concentrations 1.9 Electrical conductivity and mobility 2.0high field effects.	• The student should be able to understand basic concepts of energy bands, Quantum Well, Fermi Level and high field effect	• Able to understand basic concepts of energy bands, Quantum Well, Fermi Level and high field effect
Unit 2. Excess carriers in semiconductors 2.1 Optical absorption 2.2 Direct recombination of electrons and holes 2.3 Indirectrecombination 2.4 Trapping 2.5 Steady state carrier generation 2.6 Quasi-Fermi levels 2.7 Diffusionprocess of carriers 2.8 Diffusion and drift of carriers **2.9 Diffusion and recombination:** 2.9.1 Thecontinuity equation 2.9.2 steady state carrier injection 2.9.3 Diffusion length 2.9.4 The Haynes-Shockley experiment.	• To Help the Students to understand the Concept of Optical absorption, Steady state carrier generation, Quasi-Fermi level and diffusion process.	• The students understand basic concepts of Optical absorption, Steady state carrier generation • The students are understood Quasi-Fermi level and diffusion process
Unit 3. Dynamics of charge carriers and lattice, and Semiconductor Interfaces 3.1 Electrons in a periodic potential 3.2 Group velocity of electrons 3.3 Inverse effective masstensor 3.4 Force equation 3.5 Dynamics of electrons and holes 3.6 Effective mass theory ofimpurities 3.7 The vibrational specific heat 3.8 Thermal expansion 3.9 Thermal conductivity 3.10 Schottky barriers 3.11 Rectifying contacts	• To enable the students to understand electron in periodic motion, group velocity and dynamics of electron and holes. • To understand Thermal conductivity, expansion and Schottky Barrier	• The students are understood electron in periodic motion, group velocity and dynamics of electron and holes. • To understand Thermal conductivity, expansion and Schottky Barrier

3.12 Ohmic contacts 3.13 Surface and interface states andtheir effects on barrier height 3.14 Acceptor and donor surface states 3.15 Fermi level pinning		
Unit 4. Semiconductor crystal growth process 4.1 Nucleation and growth theory 4.2 Atomic bonding 4.3 Formationenergyof clusters 4.4 Supersaturation 4.5 Supercooling and volume energy 4.6 Stability of small nuclei 4.7 Theformation energies of liquid nuclei and crystalline nuclei 4.8 Nucleation rates 4.9 The growthof crystal surfaces 4.10 Growth of bulk semiconductors by zone melting and zone refining 4.11 Czochralski and liquid encapsulation techniques 4.12 Growth of epitaxial layers by LPE 4.13 VPE and MBE techniques**.**	• To understand Nucleation and growth theory, Atomic bonding Stability of nuclei, VPE, MBE and Supersaturation.	• Students are understood Nucleation and growth theory, Atomic bonding Stability of nuclei, VPE, MBE and Supersaturation.

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. III**		
Course No (Paper Code) : **HCT- 3.2**		
Title of Course (Name of Paper) : **Atomic and Molecular Physics**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1. Atomic Physics 1.1 Vector atom model and quantum numbers 1.2 Larmar precession 1.3Spectroscopic terms 1.4 Lande's g factor 1.5Fine structure of hydrogen atom- relativistic correction 1.6 Spin-orbitinteraction 1.7 Intensity of fine structure lines 1.8 Lamb shift 1.9Hyperfine structure of spectrallines 1.10Determination of nuclear spin 1.11Ground state of one-electron and two-electronatoms and their spectra 1.12 Perturbation theory and variational method 1.13 Para and orthostates 1.14 Pauli exclusion principle 1.15 Excited states 1.16Doubly excite states 1.17 Augereffect,resonance 1.18 Many electron atoms: Central field approximation 1.19 Thomas-Fermimodel 1.20Hartee-Fock method and self-consistent field 1.21 Hund's rule 1.22 L-S and j-jcoupling schemes 1.23Fine structure of sodium d line, 1.24 Lande interval rule 1.25The idea ofHartee-Fock equations. 1.26 The spectra of alkalis using quantum defect theory 1.27Selectionrules for electronic and magnetic multiple radiations 1.28 Oscillator strengths and ThomasReich-Kuhn sum rule.	• To Understand the atomic model: Larmar Pression, Fine structure of Hydrogen atom, Lamb Shift. • To help the student for understand the concept spectroscopic term and solving the problems on Lande's g factor • Student should be able to understand the Hunds rule, L-S, J-J Coupling Schemes and Hartee-Folk self -consistent field method	• Students are understood the concept of atomic model: Larmar Pression, Fine structure of Hydrogen atom, Lamb Shift. • Students are understood the concept of spectroscopic term and solving the problems on Lande's g factor • Student are understood the Hunds rule, L-S, J-J Coupling Schemes and Hartee-Folk self -consistent field method
Unit 2. Interaction of atoms with Electromagnetic fields 2.1 Spectra of alkali and alkaline earths elements 2.2 Complex spectra -Multiplet structure 2.3 Zeeman effect 2.4 Paschen-BackEffect 2.5 Stark effect	• The student will learn about Alkali alkaline and Complex spectra • To understand Zeeman Effect, Paschen Back Effect, Stark Effect	• The studentsare learned about Alkali alkaline and Complex spectra • Students understood Zeeman Effect, Paschen

2.6Hyperfine structure of spectral line 2.7 Broadening of spectral lines 2.8 X-ray spectra.		BackEffect & Stark Effect
Unit 3. Molecular Physics 3.1 Born-Oppenheimerapproximation 3.2 Rotation and vibration of diatomicmolecules 3.3 Electronic spin, Hund's cases and nuclear spin 3.4Electronic structure ofdiatomic molecules 3.5Structure of polyatomic molecules. 3.6 Rotational spectra: Intensityof rotational spectra 3.7 Isotopic effect of rotational spectra 3.8Non-rigid rotator andvibrational spectra: anharmonic effect 3.9 Diatomic Vibrating rotator 3.10 Breakdown ofBorn-Openhemer approximation 3.11Interaction of rotational vibration 3.12 Electronicspectra 3.13 Fortrant diagram 3.14 Atomic collisions: Types of collisions, Channels, thresholds,cross-sections, potential scattering, general features, Born approximation.	• The student will learn about Structure and Properties of diatomic, Poly atomic molecules and its spectra • To understand the concept of Zeeman Effect, Paschen Back Effect, Stark Effect	• Student are learnedthe Structure and Properties of diatomic, Poly atomic molecules and its spectra • Students understood Zeeman Effect, Paschen Back Effect & Stark Effect
Unit 4. Raman spectra and resonance spectroscopy 4.1 Raman Effect and Raman spectroscopy: 4.2 Classical and Quantum theory of RamanEffect 4.3 Rotational and vibrational structure of Raman spectrum 4.4Pure rotationalRaman spectra of diatomic molecules 4.5Vibration rotation Raman spectrum of diatomicmolecule 4.6Intensity alterations 4.7 Application of IR & Raman spectroscopy 4.8 ResonanceTechnique: NMR – nuclear spin magnetic moment 4.9Interaction of nuclear magnet withexternal field 4.10 Quantum description of N.M.R 4.11 NMR spectrometer 4.12 Chemical shift 4.13 Spin–spin interaction 4.14 Applications of NMR spectroscopy 4.15 Quantum mechanicaltreatment of Electronic spin resonance (ESR) 4.16 Nuclear interaction and hyperfinestructure 4.17 Relaxation effects 4.18 Basic principles of spectrographs - Applications of ESRmethod 4.19 Mossbauer spectra and its applications.	• The student will learn the Raman effect, Raman Spectra and its application • The studentsshould learn NMR Spectra and its application • The students understand basic principle of Spectrograph, Mossbauer spectra and its application	• The student willlearn the Raman effect, Raman Spectra and its application • The students learned anNMR Spectra and its application • The students are understood the basic principle of Spectrograph, Mossbauer spectra and its application

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. III**		
Course No (Paper Code) : S**CT- 3.2**		
Title of Course (Name of Paper) : **Experimental Techniquesfor Physics**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1. Electronic instrumentations: 1.1 *Measurement system:* mechanical and electrical, Transducers and its types, sensors,differential output transducer, LVDT, Hygrometers 1.2 Measurement of thermalConductivity (gas analyser), Physiological transducers Bio-potential electrodes 1.3 *Digital and analog measuring instruments:* voltmeter, ammeter, oscilloscope, power meter, LCR meter, instrumentationamplifier, filtering and noise reduction in instruments, shielding and grounding, lockindetector, box-car integrator, interfacing sensors and data acquisition 1.4 *Integrated circuits technology:* fabrications, Power supplies- primary and secondary cell,regulated power supply, SMPS, UPS, Step down switching regulator, Inverter'svoltagedriven inversion, current driven inversion.	• To understand measurement system of some electronic instruments • To understand analog and digital measuring instruments and integrated circuit technology like power supply, SMPS, UPS, Inverters., etc	• Students understood measurement system of some electronic instruments • Students understoodanalog and digital measuring instruments and integrated circuit technology like power supply, SMPS, UPS, Inverters., etc
Unit 2. Lasers and Optoelectronic instrumentation: 2.1 *Lasers:* - Temporal and special coherence, Einstein coefficients, 2.2 The thresholdcondition, two, three and four level laser systems 2.3 Modes of a rectangular cavity andopen planar resonator, Quality factor, mode selection, The Ruby laser, The Helium-Neon laser, the carbon dioxide (CO_2)laser. 2.4 *Optoelectronic devices:*Photoconductivity, LDR, photodiode, phototransistor,solar cell, metal semiconductordetector, LCD, CCD, LED, Laser diode, PIN photodiode, Avalanche photodiode,Heterojunction photodiode, Organic light emitting diodes, Optical fiber-raypropagation Step –index and graded-index fibers, dispersion and attenuation in fiberoptics, Dispersion compensation mechanism, Erbium-doped fiber amplifiers, Optoelectronic modulators.	• Students should learn LASER system and its types • Students should understand optoelectronic devices like Solar Cell, LDR, LCD, CCD, LED., etc	• Students learned LASER system and its types • Students are understood optoelectronic devices like Solar Cell, LDR, LCD, CCD, LED., etc
Unit 3(a). X-ray analysis: 3.1 Origin of X-rays 3.2 X-ray generators 3.3 Scattering of X-ray	• To understand concept of X-Ray generator, scattering and diffraction and its application	• To understood concept of X-Ray generator, scattering and diffraction and its

3.4Atomic scatteringfactor 3.5 Diffraction of X-ray 3.6Various X-ray diffraction methods 3.7 X-ray powderdiffraction method -indexing of powder lines 3.8 Laue's method, 3.9 Rotational/oscillationmethod 3.10X-ray diffractometer determination of crystalstructure and lattice parameter 3.11Small angle x-ray diffraction and its applications. 3.12 XPS, XRF and its applications. **3(b).Low pressure and Low temperature:** *3.13 Production of low pressure* -Rotary, oildiffusion, turbo molecular, getter and cryo pumps; gauges – Macleod thermoelectric(thermocouple, thermistor and pirani), penning, hot cathode partial pressuremeasurement; leak detection; gas flow through pipes and apertures; effective pumpspeed; vacuum components. *3.14 Production of Low temperature:* Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperaturemeasurement.	• To understand concept of XPS, XRF and its application • To understand production of low pressure and low temperature	application • To understood concept of XPS, XRF and its application • To understood production of low pressure and low temperature
Unit 4. Analytical Instrument: 4.1 Electron Microscopy (SEM,TEM, HRTEM) 4.2 Scanning probe microscopy (AFM,MFM, STM) 4.3 UV-Vis, spectroscopy and its applications 4.4 FT-IR spectroscopy 4.5 *Luminescence spectroscopy techniques*- Fluorescence spectroscopy, Ramanspectroscopy, Thermal analysis using DTA, TGA, DSC 4.6*Electronic transport analysis using Current vs Voltage characteristics*: two probe and four probe techniques - various types of contacts, Dielectric and impedance spectroscopy, spectrumanalyser,fluorescence and Raman spectrometer, Interferometers for differentanalytical study.	• Students should understand Analytical instruments like SEM, AFM, STM UV-Vis, FTIR., etc • Students should understand electronic transport analysis using current Vs voltage	• Students understood Analytical instruments like SEM, AFM, STM UV-Vis, FTIR., etc • Students understood electronic transport analysis using current Vs voltage

Signature of HOD

<table>
<tr><td colspan="3">B. A. / B. Sc. / M. A. / M. Sc: M. Sc. II</td></tr>
<tr><td colspan="3">Name of the Subject :Solid State Physics</td></tr>
<tr><td colspan="3">Semester I / II / III / IV / V / VI :Sem. III</td></tr>
<tr><td colspan="3">Course No (Paper Code) : OET- 3.2</td></tr>
<tr><td colspan="3">Title of Course (Name of Paper) : Energy Harvesting Devices</td></tr>
<tr><th>COURSE CONTENT</th><th>OBJECTIVES</th><th>OUTCOME</th></tr>
<tr><td>Unit -1: Solar Cells
1.1 Photovoltaic effect
1.2 Solar cell characterization
1.3 Types of Solar cells
1.4 Solid state solarcells Silicon solar cell
1.5 Cd-Te based solar cells
1.6CdS/Cu2S solar cells
1.7 CuInSe2 basedsolar cells
1.8 Metal-semiconductor solar cells
1.9 Photoelectrochemical and photoelectrolysis cells
1.10 Solar cells based on thin film heterojunctions
1.11Ultra-thin absorbersolar cells
1.12 Nanostructured solar cells
1.13 Dye sensitised solar cells: basic concepts,working and materials.
1.14 Organic Solar cells: basic concepts, working and materials.</td><td>• To understand characterisation and various types of Solar cells like Cd-Te, CdS, $CdInSe_2$, Dye Sensitised, Organic., etc</td><td>• The student Understood characterisation & various types of Solar cells like Cd-Te, CdS, $CdInSe_2$, Dye Sensitised, Organic., etc</td></tr>
<tr><td>Unit -2: Super Capacitors
2.1 Comparison of battery and super capacitors
2.2 Super capacitor characterization
2.3 Typesof super capacitors
2.4 Double layer and pseudo capacitance
2.5 Hybrid super capacitors
2.6Recent status of carbon
2.7 RuO_2 and polyaniline based super capacitors
2.8 Differentmethods for preparation of cathodic and anodic electrode materials
2.9 Fabrication ofsuper capacitors with examples
2.10 Applications of supercapacitors</td><td>• To Understand characterisation, various types and application of Super capacitors</td><td>• To understood characterisation, various types and application of Super capacitors</td></tr>
<tr><td>Unit -3: Fuel Cells
3.1 Comparison between fuel cells and batteries
3.2Fuel cell characterizations
3.3 Types of fuel cells: Metal oxide, proton exchange membrane, Phosphoric acid, Solid oxide fuelcells
3.4 Working of fuel cells
3.5 Materials for fuel cells
3.6Applications of fuel cells</td><td>• Students understand characterisation, various types and application of fuel cells</td><td>• Students are Understood characterisation, various types and application of Fuel cells</td></tr>
<tr><td>Unit -4: Piezoelectrics
4.1 Piezoelectric Energy Harvesting: Energy harvesting</td><td>• To Understand Piezoelectric</td><td>• To Understood Piezoelectric</td></tr>
</table>

basics 4.2 Case studyPiezoelectric Materials: Piezoelectric polycrystalline ceramics,Piezoelectric SingleCrystal Materials, Piezoelectric and Electro strictive Polymers, Piezoelectric ThinFilms. Piezoelectric transducers 4.3 Mechanical energy harvester using LaserMicromachining 4.4 Mechanical energy harvester using PiezoelectricFibers 4.5 PiezoelectricMicrocantilevers 4.6 Energy harvesting circuits 4.7 Multimodal energy harvesting 4.8 Magnetoelectric composites 4.9 Introduction to Piezoelectric bulk Power generators 4.10 Piezoelectric Micro Power Generators 4.11 Conversion efficiency 4.12 Power storage circuits	materials, power generators and power storage circuits	materials, power generators and power storage circuits

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. III**		
Course No (Paper Code) : **HCT- 4.1**		
Title of Course (Name of Paper) : **Semiconductor Devices**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1: Physics of Semiconductor Devices ***Carrier transport phenomena in semiconductor solids:***1.1 Drift and diffusion process 1.2 Carrier Diffusion 1.3 Diffusion Current Density 1.4Total Current Density 1.5 Graded ImpurityDistribution 1.6 Transport in crystalline and amorphous semiconductors 1.7 Induced ElectricField 1.8 The Einstein Relation 1.9 Temperature dependence of semiconductor conductivity 1.10 Carrier life 1.11 Shockley-Read-Hall theoryMIS Structure and MOS FETsSchottky diode 1.12 MIS structures 1.13Basic equations in flat band conditions 1.14 MIScapacitances 1.15Current flow mechanisms in MS junction and MIS junction 1.16Depletionand enhancement type MOS FETS 1.17Capacitances in MOS FETs 1.18 Quantitative analysisof I - V characteristics 1.19Thresholds in MOSFETS 1.20Charge trapping and flat bandvoltage 1.21Study of CMOS devices.	• Students understand Carrier transport phenomena in semiconductor solids • To understand Einstein relation, Temperature dependence of semiconductors conductivity and Shockley-Read-Hall theory. • To understand MIS, MOSFETS and CMOS devices	• Students understood Carrier transport phenomena in semiconductor solids • To understood Einstein relation, Temperature dependence of semiconductors conductivity and Shockley-Read-Hall theory. • To understood MIS, MOSFETS and CMOS devices

Unit 2: Power Devices 2.1 Power diodes, ratings, reverses recovery characteristics, fast recovery diodes 2.2 Power transistors, Switching characteristics 2.3 Construction of SCR 2.4 Two transistors analogy, I- V characteristics, gate trigger characteristics, turn on and turn - off times, losses, reverse recovery characteristics 2.5 SCR ratings, dv/dt and di/dt characteristics 2.6 Thyristor types 2.7Construction and characteristics of DIACs and TRIACs 2.8 Static induction thyristors 2.9 Light activated thyristors 2.10 Gate turn off thyristors (GTO) 2.11 MOS controlled thyristors 2.12 Programmable Unijunction transistors 2.13Silicon Unidirectional switch (SUS) 2.14 IGBT	• To understand the construction and I-V characteristics of SCR • Students understand the various types of thyristor like DIAC, TRIAC, GTO, MOS, IGBT, SUS., etc	• To understood the construction and I-V characteristics of SCR • Students are understood the various types of thyristor like DIAC, TRIAC, GTO, MOS, IGBT, SUS., etc
Unit 3: Charge Coupled and Transferred Electron Devices 3.1 Charge storage 3.2Surface potential under depletion 3.3Construction of basic two and threephase of CCD 3.4Mechanism of charge transfer 3.5 Oxide Charges 3.6Charge trapping andtransfer efficiency 3.7Dark current 3.8Buried channel CCD 3.9 Application of CCD 3.10 Transferred Electron Effect 3.11 NDR (Negative differential resistivity of voltage andcurrent controlled devices) 3.12 Formation of gunn domains 3.13Uniform and accumulationlayer 3.14 operation modes 3.15Transistors and quenched diodes 3.16Layers and modes ofoperation 3.17 LSA mode of operation 3.18Frequency responses and overall deviceperformance of Gunn devices.	• Students understand the construction, working and application of Charge Coupled Devices (CCD) • Students understand the Gunn domain and its operation modes	• Students understood the construction, working and application of Charge Coupled Devices (CCD) • Students understood the concept of Gunn domain and its operation modes
Unit 4:Optoelectronic and Advanced SolidState Devices 4.1 Light emitting diodes 4.2 Performance of LEDs 4.3 Emission spectra 4.4Visible and IR LEDs *4.5Semiconductor LASER:* p-n junction lasers, heterojunction lasers, materials forsemiconductor LASER, threshold current density, effect of temp.	• Students understand an Optoelectronic and advanced solid state devices like LED, LASER, Photodiode, Visible and IR LEDs., etc	• Students understood an Optoelectronic and advanced solid state devices like LED, LASER, Photodiode, Visible and IR LEDs., etc

Quantum wellhetero structures, 4.6*Detectors:*photoconductors, photocurrent gain and detectivity *4.7 Photo diode types:* p-n junction, p-i-n, avalanche characteristics, quantum efficiency,response speed, noise and optical absorption coefficient, efficiency 4.8 Solar cells –current voltage characteristics.		

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. IV**		
Course No (Paper Code) : **HCT- 4.2**		
Title of Course (Name of Paper) : **Nuclear and Particle Physics**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1. Properties of Nucleus & Nuclear Forces: 1.1 Shape and Size, mass, spin and parity 1.2 Masses and relative abundances 1.3 Bindingenergy & nuclear stability 1.4Nuclear compositions 1.5Quantum properties of nucleonstates 1.6*Radioactivity:* Laws of radioactivity, radioactive dating, radioactive series 1.7 Theory of alpha, beta & gamma decays and their properties. 1.8 Nuclear forces: Propertiesof nuclear forces, two nucleon systemsdeuteron with potentials, n-p and p-p/n-ninteractions at different energies 1.9 Yukawa's hypothesis 1.10 Meson theory of nuclear force.	• Students understand properties of Nucleus and Nuclear Forces, Yukawa's hypothesis and Meson theory of Nuclear Forces	• Students understood properties of Nucleus and Nuclear Forces, Yukawa's hypothesis and Meson theory of Nuclear Forces
Unit 2. Nuclear models: 2.1 Fermi gas model 2.2Liquid drop model and Bethe-Weizsacker formula theirapplications 2.3Shell model and shell structure 2.4Extreme single particle shell model with potentials 2.5 Square well 2.6Harmonic oscillator 2.7Spin orbit interaction 2.8 Magic numbers 2.9Predictions of the shell model 2.10Collective nuclear model 2.11Superconductivity model (ideas only).	• To understand Nuclear Models like Liquid drop, shell, collective nuclear, superconductivity., etc	• Students understood Nuclear various Models like Liquid drop, shell, collective nuclear, superconductivity., etc
Unit 3. Nuclear reactions: 3.1 Types of nuclear reactions 3.2 Conservation laws 3.3 Nuclear reaction kinematics 3.4 Nuclearscattering cross section determinations 3.5Compound nucleus disintegration 3.6BreitWigner dispersion formula (one level) 3.7Direct reactions 3.8Nuclear transmutationreactions 3.9Nuclear fission and fusion	• To understand types of Nuclear reactions like Direct reaction, Nuclear transmutation reaction and Nuclear Fission and Fusion	• To understood types of Nuclear reactions like Direct reaction, Nuclear transmutation reaction and Nuclear Fission and Fusion
Unit 4. Particle Physics & Cosmic rays:	• To understand the	• To understood the

4.1 Broad classification of elementary particles and particle interactions in nature 4.2Conservation laws 4.3Symmetry classifications of elementary particles-Gell-Mann-Nishijima scheme 4.4CPT conservation 4.5 Quark hypothesis & Quantum chromodynamics(ideas only) 4.6*Cosmic rays:* origin of cosmic rays, nature of primary cosmic rays and itsenergy distribution, its geomagnetic,latitude effect, east-west asymmetry, origin ofsecondary rays, collision with electrons 4.7 *Particle accelerators and detectors:* linearaccelerators, cyclotron, synchrotron, colliding beam accelerators (LHC), gas-filledcounters, scintillation detectors, semiconductor detectors.	concept of particle physics, Cosmic rays, particle accelerators and detectors	concept of particle physics, Cosmic rays, particle accelerators and detectors

Signature of HOD

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**		
Name of the Subject :**Solid State Physics**		
Semester I / II / III / IV / V / VI :**Sem. IV**		
Course No (Paper Code) : **HCT- 4.3**		
Title of Course (Name of Paper) : **Thin Film Physics And Technology**		
COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit - 1 Chemical Methods of Thin films synthesis 1.1 *Chemical vapor deposition:* Common CVD reactions, Methods of film preparation,laser CVD, Photochemical CVD, Plasma enhanced CVD 1.2 *Chemical bath deposition:*ionic and solubility products, preparation of binary semiconductors 1.3 *Electrodeposition:*Deposition mechanism and preparation of compound thin film 1.4 *Spray pyrolysis:* Deposition mechanism and preparation of compound thinFilms 1.5*Ion- assisted deposition* (IAD) 1.6 Laser ablation 1.7 Longmuir Blochet film 1.8 Sol- gelfilm deposition	• To understand the Chemical methods of thin film synthesis of CVD, CBD, Electrodeposition, Spray pyrolysis, IAD, Sol-gel., etc	• To understood the Chemical methods of thin film synthesis of CVD, CBD, Electrodeposition, Spray pyrolysis, IAD, Sol-gel., etc
Unit -2 Physical Methods of Thin Film Synthesis 2.1 Introduction to Thin Films 2.2*Thermal evaporation methods*: Resistive heating, Flashevaporation, Laser evaporation, Electron bombardment heating, Arc evaporation 2.3*Sputtering process:* Glow discharge, DC sputtering, Radio frequency sputtering,Magnetron sputtering, Ion beam sputtering.	• To understand the Physical methods of thin film synthesis like Thermal evaporation and Sputtering process	• To understood the Physical methods of thin film synthesis like Thermal evaporation and Sputtering process
Unit -3 Physics of Surfaces, Interfaces and Thin films 3.1 *Mechanism of thin film formation:* Formation stages of thin films, Condensationand nucleation, Thermodynamic theory of nucleation, Growth and coalescence ofislands, Influence of various factors on final structure of thin films, Crystallographicstructure of thin films. 3.2 *Properties of thin films:* Conductivity of metal films,Electrical properties of semiconductor thin films, Transport in dielectric thin films,Dielectric properties of thin films, Optical properties of thin films 3.3 Thin films ofhigh temperature superconductors 3.4 Diamond like carbon thin films	• To understand the mechanism of thin film formation and its properties • Students understand the Physics of Surfaces, Interfaces and thin films	• To understood the mechanism of thin film formation and its properties • Students understood the Physics of Surfaces, Interfaces and thin films
Unit - 4 Thin films for Devices & other Applications 4.1 *Dielectric deposition:* silicon dioxide, silicon nitride, silicon oxynitride, polysilicondeposition, metallization, electromigration, silicides 4.2 Thin film transistors 4.3 Thin filmmultilayers 4.4Optical filters, mirrors, sensors and detectors	• To understand the Dielectric deposition of various Silicon precursors & its application in electronic devices	• To understood a Dielectric deposition of various Silicon precursors & its application in electronic devices

B. A. / B. Sc. / M. A. / M. Sc: **M. Sc. II**	
Name of the Subject :**Solid State Physics**	
Semester I / II / III / IV / V / VI :**Sem. IV**	
Course No (Paper Code) : S**CT- 4.1**	
Title of Course (Name of Paper) : **Materials Characterization Techniques**	

COURSE CONTENT	**OBJECTIVES**	**OUTCOME**
Unit 1: Microscopic Techniques I 1.1*Optical Microscopy and limitations:* Principle of Diffraction of light, Airy Disc,Resolution and magnification; Rayleigh Criteria, Numerical aperture, Major lensdefects. Different kinds of optical microscopes (Bright field,Stereo, Phase contrast,Differential Interference Contrast,Fluorescence,Confocal,Polarizing lightmicroscope) 1.2*Electron Microscopy:* Limitations of Light microscopy and advantages of electronmicroscopy. Wavelength of electrons, Theoretical Resolving power, Source ofelectron emission.Electron Focusing, Effect of magnetic fields, Electrostatic andmagnetic focusing, Optical Column, Magnetic lenses.Vacuum requirements. Schematic of complete SEM 1.3 Scanning Electron Microscopy (SEM): Interaction of electrons with matter. Secondaryelectron emission(SEE),Yield of SEE,Universal yield curve, Beam scanning and Magnification in SEM, Secondary electrons Detector, Back scattered electronsdetector.Electronics Image analysis.Size histogram. Sample preparation	• To understand the basic concept of optical microscopy & various types of optical microscopy • To understand advantages of electron microscopy over light microscopy • To understand Scanning electron microscopy, Sample preparation, Electronics Image analysis and size of histogram	• To understood the basic concept of optical microscopy &various types of optical microscopy • Students understood advantages of electron microscopy over light microscopy • To understood Scanning electron microscopy, Sample preparation, Electronics Image analysis and size of histogram
Unit 2: Microscopic Techniques II 2.1*Transmission Electron Microscopy(TEM):* Principle of operation, Lens systems, Schematic of TEM,Apertures, Bright FieldImage, Dark Field Image,Electron Diffraction, Bragg's Condition, Selective AreaElectron Diffraction (SEAD), Image analysis. Sample preparation 2.2*Scanning Tunneling Microscopy (STM):* Historical perspective, Electron tunneling,Principle of STM imaging, STM imageinterpretation,STM implementation in instrument, Pizoelectric drive, Tippreparation, Vibration isolation, Data acquisition and analysis,Application of STM,high resolution imaging of surfaces, Spectroscopy, Lithography,Currentfluctuation,Limitation of STM and solution 2.3*Atomic Force Microscopy(AFM):*	• To understand Transmissionelectron microscopy, Sample preparation, Electronics Image analysis and size of histogram • To understand Scanning tunneling microscopy and AFM(Sample preparation, Electronics Image analysis and its practical application)	• To understand Transmissionelectron microscopy, Sample preparation, Electronics Image analysis and size of histogram • To understood Scanning tunneling microscopy and AFM (Sample preparation, Electronics Image analysis and its practical application)

Principle and equations of force curves,Contact and non-contact modes, Amplitudemodulation and Frequency modulation,Forfe versus distance curve,Experimentaldetails of AFM, Practical applications.		
Unit 3: X-Ray Photoelectron Spectroscopy 3.1 Definition of surface 3.2 Different Probes for Surface-characterization 3.3 Necessity of UltraHigh Vacuum 3.4 Photoelectron Emission 3.5 Introduction and Basic Theory 3.6 HistoricalPerspective 3.7Instrumentation 3.8Vacuum System 3.9 Energy analysers 3.10 X-RaySource 3.11Electron Energy Analyzer 3.12 Sample Selection and Preparation, 3.13 SampleCharging 3.14 X-Ray Beam Effects 3.15 Spectral Analysis 3.16Core Level Splitting 3.17Linewidths. 3.18 *Elemental Analysis:* Qualitative and Quantitative, Secondary Structure, Angle-Resolved XPS, Depth profiling. *3.19 Auger Electron Spectroscopy:* Basic principle, Auger Transitions, Kinetic Energies of Auger Electrons, Sensitivityof detection, Instrumentation, Electron Energy Analyzers,Electron Detector, Sample preparation, Data analysis, Qualitative and Quantitative analysis.	• The students understand electron emission, Instrumentation, energy analyser and spectral analysis in XPS • To understand XPS and its elemental analysis • The students understand AES (Basic principle, Auger transition, Instrumentation and data analysis)	• The students understand electron emission, Instrumentation, energy analyser and spectral analysis in XPS • To understood XPS and its elemental analysis • The students understood AES (Basic principle, Auger transition, Instrumentation and data analysis)
Unit 4: Resonance spectroscopy 4.1 *Nuclear magnetic resonanceSpectroscopies.*Properties of Nuclear Spins,Nuclear Spin Interactions in Solids General Structure ofthe Internal Hamiltonians, Quantum Mechanical Calculations, Quantum MechanicalDescription of NMR, The NMR Signal—Zeeman Interaction,High Resolution SolidState NMR Methods, Dipolar Decoupling,Magic-Angle Spinning (MAS), Cross-Polarization (CP), The CP-MAS Experiment,NMR Spectra. 4.2 *EPR Spectroscopy:* EPR Condition, Continuous Wave-EPR, EPR Lineshape: Relaxation Times 4.3 Electron-Nuclear Interactions: Hyperfine Structure	• Students understand Resonance Spectroscopy (NMR) and its spectra • Students understand Resonance Spectroscopy (EPR) and its spectra	• Students understood Resonance Spectroscopy (NMR) and its spectra • Students understood Resonance Spectroscopy (EPR) and its spectra

Signature of HOD

D.B.F. Dayanand College of Arts and Science, Solapur

Department of Physics

Program Outcome: M. Sc. Physics

The Master of Science in Physics programme provides the candidate with required knowledge, general competence and analytical skills on an advanced level, needed in industry, consultancy, education, research, or in public administration.

On completion of program of the post graduates will

- The students would gain substantial knowledge in various branches of physics: Solid State Physics, Electronics,Quantum, Classical, Statistical Mechanics, Mathematical Physics,Nuclear and Particle Physics and Energy Sources.
- Would Learn to carry out experiments in basic as well as certain advanced areas of physics such as Material Science, Nuclear Physics, Electronics and High Temperature Devices.
- This course would empower the student to acquire scientific and engineering skills and therequired practical knowledge by performing experiments in Solid State physics and Electronics.
- Would also get some research-oriented experience by doing theoretical and experimental projects in the last semester under the supervision of faculty.
- The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors.
- Students may get job opportunities in higher education, research organizations, physics
  consultancy, radiologyand many others. Some of the institutions where physics students can start their carrier are: BARC, DRDO, TIFR, NPTC, IISc, ISRO, ONGC, BHEL, PRL, NPL, SINP, VECC,NITs, IIPR etc.

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
॥ विद्यया संपन्नता ॥

NAAC Accredited-2015
'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: Physics (Nano Physics, Solid State)

Name of the Course: M.Sc. I (Sem– I & II)

(Syllabus to be implemented from w.e.f. June 2020-21)

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY

Syllabus of M.Sc. Physics (Nano Physics, Solid State)

Choice Based Credit System

1) **Title of the course:** M.Sc. in Physics (Nano Physics, Solid State)
2) **Duration of the course**: Two years.
3) **Pattern:** Choice Based Credit System (CBCS)
4) **Eligibility:** For M. Sc. in Physics following candidates are eligible.
   (i) B.Sc. with Physics at principal level.

5) **Intake Capacity:** 20

M. Sc. program in Physics consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Physics Course

Semester	No. of Papers/ Practicals / Seminar	Marks	Credits
Semester I • Theory Papers • Practical Papers • Seminar/Tutorial	04 04 01	400 200 25	16 08 01
Semester II • Theory Papers • Practical Papers • Seminar/ Tutorial	04 04 01	400 200 25	16 08 01
Semester III • Theory papers • Practical Papers • Seminar/ Tutorial	04 04 01	400 200 25	16 08 01
Semester IV	04	400	16

• Theory papers • Project • Seminar/ Tutorial	04 01	200 25	08 01
Total marks and credits for M.Sc. Course		**2500**	**100**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

M. Sc – Physics (Nano Physics)

Choice Based Credit System

w.e.f June 2020-21

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
First		**Hard core**	**Theory**	**IA**	**Total**				
NP	**HCT1.1**	Mathematical Physics	80	20	100	4		-	4
	HCT1.2	Solid State Physics	80	20	100	4		-	4
	HCT1.3	Analog & Digital Electronics	80	20	100	4		-	4
		Soft Core (Any one)							
	SCT1.1	Classical Mechanics	80	20	100	4		-	4
	SCT1.2	Elements of Material Science	80	20	100	4		-	
		Tutorial		25	25		1	-	1
		Practical							
	HCP 1.1	Practical HCP 1.1	40	10	50	-	-	2	6
	HCP1.2	Practical HCP 1.2	40	10	50	-	-	2	
	HCP1.3	Practical HCP 1.3	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP1.1	40	10	50	-	-	2	2
	SCP1.2	Practical SCP1.2	40	10	50	-	-	2	
		Total for first semester	**480**	**145**	**625**				**25**
Second		**Hard core**							
NP	**HCT2.1**	Quantum Mechanics	80	20	100	4		-	4
	HCT2.2	Electrodynamics	80	20	100	4		-	4
		Soft core (Any one)							
	SCT2.1	Statistical Physics	80	20	100	4		-	4
	SCT2.2	Analytical Techniques	80	20	100	4		-	
		Open elective (Any one)							
	OET2.1	Fundamentals of Electronics	80	20	100	4		-	4
	OET2.2	Conventional & Non conventional Energy	80	20	100	4		-	
		Tutorial		25	25		1	-	1
		Practical							
	HCP 2.1	Practical HCP 2.1	40	10	50	-	-	2	4
	HCP2.2	Practical HCP 2.2	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP2.1	40	10	50	-	-	2	
	SCP1.2	Practical SCP2.2	40	10	50	-	-	2	2
		Open elective (Any one)							
	OEP2.1	Practical OEP2.1	40	10	50	-	-	2	2
	OEP2.2	Practical OEP2.2	40	10	50	-	-	2	
		Total for second semester	**480**	**145**	**625**				**25**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

M. Sc – I Physics (Solid State) w.e.f June 2020-21

Choice Based Credit System

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
First		**Hard core**	**Theory**	**IA**	**Total**				
SS	**HCT1.1**	Mathematical Physics	80	20	100	4		-	4
	HCT1.2	Solid State Physics	80	20	100	4		-	4
	HCT1.3	Analog & Digital Electronics	80	20	100	4		-	4
		Soft Core (Any one)							
	SCT1.1	Classical Mechanics	80	20	100	4		-	4
	SCT1.2	Elements of Materials Science	80	20	100	4		-	
		Tutorial		25	25		1	-	1
		Practical							
	HCP 1.1	Practical HCP 1.1	40	10	50	-	-	2	6
	HCP1.2	Practical HCP 1.2	40	10	50	-	-	2	
	HCP1.3	Practical HCP 1.3	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP1.1	40	10	50	-	-	2	2
	SCP1.2	Practical SCP1.2	40	10	50	-	-	2	
		Total for first semester	**480**	**145**	**625**				**25**
Second		**Hard core**							
SS	**HCT2.1**	Quantum Mechanics	80	20	100	4		-	4
	HCT2.2	Electrodynamics	80	20	100	4		-	4
		Soft core (Any one)							
	SCT2.1	Statistical Physics	80	20	100	4		-	4
	SCT2.2	Analytical Techniques	80	20	100	4		-	
		Open elective (Any one)							
	OET2.1	Fundamentals of Electronics	80	20	100	4		-	4
	OET2.2	Conventional & Non conventional Energy	80	20	100	4		-	
		Tutorial		25	25		1	-	1
		Practical							
	HCP 2.1	Practical HCP 2.1	40	10	50	-	-	2	4
	HCP2.2	Practical HCP 2.2	40	10	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP2.1	40	10	50	-	-	2	
	SCP1.2	Practical SCP2.2	40	10	50	-	-	2	2
		Open elective (Any one)							
	OEP2.1	Practical OEP2.1	40	10	50	-	-	2	2
	OEP2.2	Practical OEP2.2	40	10	50	-	-	2	
		Total for second semester	**480**	**145**	**625**				**25**

Evaluation Scheme:

Each theory paper will have 100 marks out of which 80 marks will be for Term End examination and 20 marks for Internal Assessment. The candidate has to appear for internal evaluation of 20 marks and external evaluation (University Examination) of 80 marks for each theory paper.

Each practical paper will have 50 marks out of which 40 marks will be for Term End examination and 10 marks for Internal Assessment. The candidate has to appear for internal evaluation of 10 marks and external evaluation (University Examination) of 40 marks for each practical paper.

Internal Evaluation:

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical papers, 5 marks shall be for day-to-day journal and 5 marks shall be for internal test, which will be conducted by the department / school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each Theory paper is of 80 marks.
2) Each Theory paper will be of 3 hours.

II) Nature of Practical question paper: (End of Term Examination)

Sem-I and II: Practical examination (Performing of Experiments) will be conducted for 40 marks and is of two hours duration. VIVA will be for 10 marks.

________________xxxx________________

M.SC-I, SEME. I, PHYSICS (Nano Physics,Solid State)
HCT - 1.1: MATHEMATICAL PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Calculus of Residues (15)

COMPLEX VARIABLE AND REPRESENTATIONS: Algebraic Operations, Argand Diagram: Vector Representation, Complex Conjugate, Euler's Formula, De Moiver's Theorem, The n^{th} Root or Power of a complex number.

ANALYTICAL FUNCTIONS OF A COMPLEX VARIABLE : The Derivative of f(Z) and Analyticity, Harmonic Functions, Contour Integrals, Cauchy's Integral Theorem, Cauchy's Integral Formula,

Zeros, Isolated Singular points, Evaluation of Residues, Cauchy's Residue theorem.

Unit II : Operator and Matrix Analysis (15)

Vector Space and its dimensionality, Vector Spaces and Matrices, Linear independence; Bases; Dimensionality, linear dependence, Inner product Hilbert space, linear operators.

Matrix operations, properties of matrices, Inverse, Orthogonal and unitary matrices; Independent elements of a matrix Diaglonization; Complete orthogonal sets of functions, special square matrices, Eigen values and eigenvectors; Eigen value problem.

Unit III: Ordinary Differential Equations (14)

First-Order homogeneous and non homogeneous equations with variable coefficients. The superposition principle, Second-order homogeneous equations with constant coefficient. Second-order non homogeneous equations with constant coefficients.

Unit IV: Fourier Series, Integral Transforms and Laplace transform (16)

Fourier Series: Fourier's theorem; Cosine, Sine and complex Fourier series, Applications to saw tooth and square waves and full wave rectifier. FS of arbitrary period; Half wave expansions; Partial sums Fourier integral and transforms; cosine since complex forms, Parsevals relation, Application to Gaussian distribution, box and exponential functions; FT of delta function.

Laplace transforms: Laplace transforms of common functions, First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function.

Reference Books:

1. Introduction to Mathematical Physics by C. Harpcr, Prcnticc - Hall of India Ltd. N.Delhi 1993,(Chapters 2,4,6,9)

2. Mathematical Physics by A.G. Ghatak, I.C.Goyal and S.J.Chua, McMillan India Ltd. New Delhi 1995 (Chapters 4,7,9,10)

3. Matrices and Tensors for Physicists,by A W Joshi

4. Advanced Engineering Mathematics, by E Keryszig

5. Mathematical Method for Physicits and Engineers, by K F Reily, M P Hobson and S J Bence

6. Mathematics for Physicists by Mary L B

7. Mathematical Methods for Physics, by G Arfken

M.SC-I, SEME. I, PHYSICS (Nano Physics,Solid State)
HCT - 1.2: SOLID STATE PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Crystal Structure (15)

Basic Structures, Bravais systems in 2D and 3D, Bonding in solids, Reciprocal Lattice, Diffraction by X-ray and structure factor, Point defects and dislocations,

Specific Heat: Lattice vibration, Phonons, Einstein and Debye's theories.

Unit II: Energy bands and Semiconductors (20)

Energy bands:

Metal, Insulator and Semiconductor, Bloch theorem, Electron in periodic potential -1D, Tight and loose band approach, Brillion's Zones, Fermi surfaces.

Semiconductors:

Direct and indirect band gap semiconductors, Effective mass, Hall effect and thermoelectric power, Intrinsic and Extrinsic carrier concentration.

Unit III: Dielectrics (10)

Electronic, Ionic, Orientational polarizations, Clausius-Mossotti equation, Dipole theory of ferroelectricity, Internal field in solids, Classification of magnetic materials,

Unit IV: Superconductors (15)

Basic concept, Meissner effect, Types I and II, Thermal properties of superconductor, Thermodynamics of superconductors, London equation, Josephson tunneling and its theory, BCS theory.

Reference Books:

1) Introduction to Solid State Physics 4 th Ed. C.Kittel,

2) Solid State Physics by N.W.Ashoroff &N.D.Mermin

3) Solid State Physics S.O.Pillai (New age international limited Publications)

4) Solid State Physics by Saxena and Gupta(Pragati Editions)

5) Solid State Physics by Rita John (Mc Graw Hill)

M.SC-I, SEME. I, PHYSICS (Nano Physics,Solid State)
HCT - 1.3: ANALOG & DIGITAL ELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

Unit I: Operational Amplifiers (15)Differential amplifier Circuit Configurations, Dual Input Balanced Output Differential amplifier, DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circ

Block diagram of a typical Op-Amp, Open loop configuration, Inverting and Non-inverting amplifiers, Op-amp with negative feedback, Voltage Series Feedback, Effect of feedback on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower.

Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.

Unit II: Applications of Op amps (15)

DC and AC amplifier, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator.

Oscillator: Principles, Oscillator types, Frequency stability, Response, Phase Shift oscillator, Wein Bridge Oscillator, LC Tunable Oscillator, Multivibrators, Monostable and Astable, Comparators,

Unit III: Combinational & Sequential Logic Circuits (15)

Combinational logic:

The transistor as a switch, OR AND NOT gates- NOR And NAND gates Boolean algebra- Demorgans theorems, Multiplexers and Demultiplexers

Sequential Logic: Flip-Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flops Flip-Flop,
D Flip- Flop, Shift registers Synchronous and Asynchronous counters.

Unit IV: Microprocessors (15)

Architecture of 8085, Signals and timing diagram of 8085, Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly Language Programming of 8085 (Sum /Subtraction, Multiplication & Division of 4 & 8 bit numbers) . **Reference Books:**

1) OP Amp amplifiers by RamakantGaikwad
2) Integrated Circuits by K.R.Botkar
3) Modern Digital Electronics by R.P.Jain
4) Digital Principle and Application by Malvino&Leeach
5) Digital Fundamentals by Floyd
6)8085 Microprocessor by Ramesh Gaonkar

M.SC-I, SEME. I, PHYSICS (Nano Physics,Solid State)
SCT - 1.1: CLASSICAL MECHANICS

Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I : Mechanics of Particles and Rigid Bodies (15)

Mechanics of Particle and system of Particles using vector algebra and vector calculus, Conversion laws, work-energy theorem, open systems (with variable mass), Gyroscopic forces; dissipative systems, Jacobi integral, gauge invariance, integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II: Lagrangian Formulation and Motion Under Central Force
(15)

Constrainsts, Generalised co-ordinates, D Alemaberts Principle, Lagranges equations of motion, Central Force, definition and characteristics, Reduction of Two-bod problem into equivalent One-body problem, General analysis of orbits, Keplers laws and equations, Artificial satellites, Rutherford Scattering.

Unit III: Variational Principle (15)

Introduction to Calculus of variation, Variational technique for many independent variables, Eulers Lagrange differential equation, Hamilton's principle, Deduction f Lagrange's equation of motion from Hamilton's principle.

Hamilton, Generalized momentum, Constant of motion, Hamilton's canonicl equations of motion, Deduction of canonical equations from Variations principle.

Applications of Hamilton's equations of motion, Principle of least action, Proof of principles of least action, Problems.

Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory (15)

Canonical Transformations, Condition for Transformation to be Canonical, Illustration of Canonical Transformation, Poisson's Brackets, Properties of Poisson's Brackets, Hamilton's Canonical equations in terms of Poisson's Brackets. Hamilton's - Jacobi Theory, Solution of harmonic oscillator problems by HJ Method, Problems.

Texts and Reference Books:

1. Classical Mechanics, By Gupta, Kumar and Sharma (Pragati Prakashan2000).
2. Introduction to Classical Mechanics, by R.G. Takwale and P S Puranik(Tata McGraw Hill 1999).
3. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
4. Classical Mechanics, by N C Rana and P S Joag(Tata McGraw Hill 1991).
5. Mechanics, by A Sommerfeld (Academic Press 1952)

M.Sc-I, SEME. I, PHYSICS (Nano Physics,Solid State)
SCT– 1.2 (MS): ELEMENTS OF MATERIALS SCIENCE
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction to materials: Classification, Properties and Requirements (15)

Introduction, Classification of Engineering Materials, Metals, Alloys, ceramics, Polymers and Semiconducting materials, Application of Engineering Materials.

Chemical Bonding: Introduction, Crystalline and Non-crystalline Solids, Classification of Bonds, Ionic Bond or Electrovalent Bond, Covalent Homopolar Bonds, Metallic Bonds, Molecular Bonds, Hydrogen Bond, van der Walls bond (Inter-molecular and Intra-molecular bonds).

Unit II: Optical Properties of Materials (15)

Introduction, Classification of Optical Materials, Interaction of light with matter, Absorption in Metals, Insulators and Semiconductors, Reflection, Refraction, Transmission and Scattering, Traps, Excitons, Colour Centers, Tauc and Lambert-Beer laws, Optical properties of Photonic material.

Luminescence and Photoconductivity Luminescence: Introduction, Principle, Classification of Luminescence, Photoluminescence, Cathodoluminescence, Electroluminescence, Thermoluminescence, Phosphorescence, Chemiluminescense, Applications.

Photoconductivity: Introduction, Photoconductivity, Characteristics of Photoconductivity Materials, Photodiodes, Photoresistor, Photodetectors, Photodetector Bias Circuit, Performance of Photodetector, Applications, Light emitting diodes (LED) and LASER's.

Unit III : Functional Materials (15)

Nanophase Materials: Introduction, Synthesis and techniques, Nucleation and growth mechanism, Characterization of Nanostructured Materials, Properties of Nanophase Materials, Applications.

Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications.

Polymer Materials: Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of commercial polymers-viz-polyethylene. Polyvinylchloride, Polystyrene, Nylon, Polyesters, Silicones, Composites, Composite material including nano-materials.

Unit IV: Phase diagrams & Diffusion in Solids (15)

Phase diagrams

Phase rule, Single component system, Binary phase diagram, Microstructure changes during cooling, Lever rule, Phase diagram rules, Applications of phase diagram.

Diffusion in solids

Ficks law of diffusion (1 st& 2 nd), Applications of second law of diffusion, Kirkendall effect, Atomic model of diffusion.

Reference Books:

1. Materials Science : V. Rajendran, A. Marikani, Tata MC Graw Hill
2. Materials Science & Engineering: Raghavan, Tata MC Graw Hill
3. Materials Science: Arumugam
4. Materials Science & Metallurgy : O. P. Khanna
5. Materials Science and Engineering: Callister S.

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)

HCT - 2.1: QUANTUM MECHANICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Unit I : Introductory Quantum Mechanics (16)

Waves and quanta: Wave and particle nature of radiation, Wave equation, Interpretation and properties of wave function; Heisenberg uncertainty principle. Operators, postulates of quantum mechanics, some important theorems, Eigen functions of the position operator and Dirac delta function. (AKC, pp 1-32)

Unit II: Wave Mechanics of simple systems (16)

One dimensional Box, Normalization and orthogonality, Discussion of the factors influencing colour. One dimensional harmonic oscillator, Normalization and Characteristics of eigen functions of harmonic oscillator, Hydrogen - like atoms, Total wave function of hydrogen-like atom, Prob. Density of 1s atomic orbital, shape of atomic orbital, physical interpretation of hydrogenic orbital, space quantization, electronic spin, Vibration and vibrational spectra of diatomic molecules. [AKC,pp:33-91]

Unit III : Many electron atoms (12)

Wave function of many electron systems, Helium atom, Many electron atoms, Hartree and HartreeFockself consistent field methods. [AKC, pp: 120-130)

Unit IV: Molecular Orbitals (16)

The Born- Oppenheimer approximation, Molecular orbital theory, Hydrogen molecule ion, Hydrogen Molecule - Molecular Orbital -Valance Band methods. [AKC, pp: 151-180]

Text Books:

1. Introductory Quantum Chemisty (3rd Ed^{n}), A. K. Chandra (Tata McGraw Hill).

2. Quantum Chemistry (4th Edition) - Ira N. Levine (Prentice Hall) of India Pvt. Ltd. New Delhi. 1995.

3. A textbook of Quantum Mechanics - P M Mathews, K Venkatesan. (Tata McGraw Hill).

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)
HCT - 2.2: ELECTRODYNAMICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Multipole expansions and time varying fields (15)

Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, boundary conditions, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, differential and integral forms of Maxwell's equations, Maxwell's equations for moving medium.

Unit II: Energy, force, momentum relations and electromagnetic wave equations (15)

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy, Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Unit III: Inhomogeneous wave equations (15)

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields.

Unit IV: Radiation emission (15)

Radiation from an oscillating electric dipole, radiation from a half wave antenna, radiation from a group of moving charges, radiation damping, Thomson cross-section.

Text Book:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith Publication: Prentice-Hall of India, New Delhi.

Reference Books:

2. Introduction to Electrodynamics, by A.Z.Capri and P.V.PanatNarosa Publishing House.
3. Classical electricity & Magnetism, by panofsky and Phillips, Addison Wesley.
4. Foundations of Electromagnetic theory, by Reitz & Milford, World student series Edition.
5. Classical Electrodynamics, by J.D.Jackson, 3rd Edition John Wiley.
6. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.
7. Electromagnetics by B.B.Laud, Willey Eastern.
8. Electrodynamics by Kumar Gupta and Singh.

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)

SCT - 2.1: STATISTICAL PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Unit I: Statistical Thermodynamics: (20)

2. Thermodynamic systems and equilibria, Laws of thermodynamics and their consequences, Nernst heat theorem, Microstates and microstates, Postulate of equal priori probability, Probability calculations, Thermodynamic potentials and Maxwell's relations, Chemical potential, phase equilibria, Black Body radiation and planks distribution, Phase equilibria, Free energy and its connection with thermodynamic quantities, entropy of mixing and Gibbs and paradox.

3.

4. Unit II: Classical statistical mechanics: (15)

5. Statistical ensembles, Microcanonical ensemble- system in contact with heat revisor, Condition for thermal equilibrium, canonical ensemble – molecular ideal gas and grand canonical ensemble, Liouville's theorem, Ensembles, Maxwell Boltzmann distribution, classical ideal gas,

6.

7. **Unit III: Quantum Statistical Mechanics (15)** Phase space (Diagram of an oscillator), Maxwell- Boltzmann statistics, Fermi-Dirac statistics and Bose- Einstein statistics, Liouville's theorem, Ideal Bose gas, Ideal Fermi gas- weekly and strongly degerate , Bose- Einstein condensation.

8.

9. **Unit IV: Phase transitions and critical phenomena (10)** Phase transition, Triple Point, Condition for phase equilibrium, First order phase transition, Ehrenfests equations, Clausius- Clayperon equation, Second latent heat equation, Examples, Second order phase transition, Critical indices, The law of corresponding states.

Reference Books:

1) Introduction to Statistical Mechanics by B.B.Laud

2) Statistical Mechanics by S.K.Sinha

3) Statistical Mechanics by I.D. Landau &F.M.Lifshitz

4) Text Book of statistical mechanics. Suresh Chandra, CBS Publications

5) Elementary Statistical Mechanics Gupta, Kumar, Pragati Prakashan.

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)
SCT - 2.2: ANALYTICAL TECHNIQUES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: X-ray Diffraction techniques (18)

Review of basic crystal systems, powder diffraction method, instrumentation of X-ray diffractometer, sources of X-rays, detectors of X-rays, acquisition of raw data, data processing and refinement.

Determination of lattice parameters and crystal structure of cubic systems, structure factors, systematic absence of reflections, intensity calculations for cubic system, determination of particle size using X-ray diffractograms, basic concept for determination of lattice parameters for other crystal systems, use of soft-ware packages.

Unit II: Infra-red spectroscopy & Ultraviolet and visible spectrophotometry (18)

Infra-red spectroscopy (IR):

Introduction, Beer Lamberts law, Instrumentation, calculation of absorption maximum of dienes, dienons and polyenes, Qualitative and Quantitative applications.

Ultraviolet and visible Spectrophotometry (UV/Vis.):

Introduction, instrumentation, sampling technique, selection rule, types of bonds, absorption of common functional groups, Factors frequencies, applications.

Unit III: Fourier - Transform Infra Red Spectroscopy (FTIR) and Raman spectroscopy (12)

Basic principle, instrumentation configuration date interpretation and analysis, and special techniques such as Attenuated Total Reflection (ATR).

Unit IV: X-ray photoelectron spectroscopy (XPS) (10)

Basic principle, instrumentation configuration, data interpretation and analysis, chemical shift, quantification, and depth-profiling.

Reference Books:

1) Elements of X –ray diffraction: B.D. Cullity, Addison-Wiely Publisher
2) Encyclopedia of materials characterization: Surfaces, Interfaces, Thin Films C. Richard Brundle, Charles A. Evans, Jr. Shaun Wilson, BUTTERWORTH-HEINEMANN
3) Nanotechnology: Principles and Practices: S.B.Kulkarni, Capital Publishing Company

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)
OET - 2.1 : FUNDAMENTALS OF ELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

UNIT 1 : Electronic Components (15)

Circuit concept Units, Standards and Dimensions. Electric current, Electric charge, potential difference, Electric power and Energy. Circuit elements : Passive elements and active elements. Network Law's, Junction Law's (KCL), Mesh Law's (KVL) Application of Network Law's to simple dc networks theorems – Thevenin's theorem, Norton's theorem Max power transfer theorem.

UNIT 2 : Semiconductor Devices (15)

Junction Diodes, p-n junction, an unbiased p-n junction, a biased p-n junction and V-I characteristics of p-n junction. Some special P-N junction: - Photodiodes, LED and Solar Cell. Junction transistor, Transistor static characteristic Self-bias or emitter bias, Two-port representation of Transistor (hybrid parameter) JFET: Static Characteristic of FET comparison of FET with Bipolar transistor.

UNIT 3: Applications of Active & Passive (15)

Operational Amplifier Characteristics and Applications

Introduction, Ideal Op-Amp, DC and AC Characteristics: Instrumentation Amplifier, V to I and I-V converter Precision rectifier, Differentiator and Integrator. Comparator Schmitt trigger wave generators (Square wave and Triangular wave) and first order Low pass and High pass filters.

UNIT 4: Special IC series (15)

Op-Amp regulator, Design of power supplies using voltage regulator ICs, 555 Timer as Monostable and Astable operation.

Reference books:

1. D Chattopadhyaya, P.C. Rakshit, B Saha and N NPurkait: Foundations of Electronics, New Age International Edition.

2. D. Roy Choudhary and ShailJain : Linear Integrated Circuit, New Age International (P) Ltd.

3. P-Amp and Linear Integrated Circuits : R. A. Gaikwad, PHI of India Ltd.

4. A Texbook of Electronics (Second Edition) : S. L. Kakani and K. C. Bhandari

5. Electronic Principles : A. P. Malvino, TMH Edition.

M.SC-I, SEME. II, PHYSICS (Nano Physics,Solid State)
OET - 2.2: Conventional & Nonconventional Energy
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit 1: Elementary electronics and electronic gadgets (Principles and Working)

(15)

Different electronic components, semiconductors, different type of diodes, rectifiers, filters, pnp and npn transistors, amplifiers, oscillators. Catoderay Oscilloscope. Concept of modulation and demodulation. Transponder. Integrated circuits. Android phones, Bluetooth. Global Positioning System. Optical fibres Endoscope. Number systems. Decimal, Hexal and Octal systems.

Unit2: Energy Resources (15)

Conventional and Renewable energy resources. Coal, Oil and Natural gas. Oil exporting and importing countries. Oil pipe lines. World reserve estimates. Non conventional energy resources. Wind power and Solar power. Solar cell Ocean thermal energy conversion, energy from waves and tides. Biomass energy. Biogas plant. Ethanol as a fuel.

Concept of nucleus. Atomic number, mass number, isotopes and isobars. Natural and artificial isotopes. Radioactivity, carbon dating. Uses of isotopes. Enriched Uranium. Fission. Simple nuclear reactions. Chain reaction. Nuclear Reactors, moderators. Heavy water and Pressurized heavy water reactor. Breeder reactor. Weapons of mass destruction. Effects of atomic bombs explosions on Hiroshima and Nagasaki. Fusion reaction. Safety of nuclear reactors. Indian nuclear program.

Unit 3: Our Universe (15)

Units of stellar distances solar system earth's atmosphere. Variation of temperature and pressure with height. Different parts of atmosphere. Earth's magnetic field. Aurora Borealies. Characteristics of different planets. Asteroides. Comets, Meteorides. Stars. Binary and Multiple stars system Lunnosities of stars. Hertzsprung-Russell diagram. Evolution of stars. Neutron star, white dwarf and blackhole. Pulsars. Chandrashekhar limit. Galaxies and their classification. Hubble's law. Origin of universe (qualitative) Electromagnetic spectrum. Radio and Optical window. Reflecting and refracting telescopes. Different mountings. Radio telescopes. Few world famous telescopes. Mount Palomer, Jodrell bank and Keck telescopes. Few Indian telescopes: Kodaikanal, Kawalur, Leh, Gurushikar and Udaipur telescopes. Radio Telescope at Narayangaon.

Unit 4: Space Exploration (15)

Newtons laws of motion, law of gravitation and other kinematic equations. Free fall under gravity. Escape velocity. Keplers laws. Satellites natural and artificial. Different orbits. Near earth orbit, geosynchronyous orbit and polar orbit. Near earh orbit satellites. GTO satellites. Remote sensing satellites and their role in measurements of national resources and mapping. Rockets. Fuels used in rockets. Chandrayan, Mangalyan, Astrosat. Missiles and their classification. Indian Space program.

M.SC-II, SEME. III, PHYSICS (Nano Physics,Solid State)

HCT - 3.1: SEMICONDUCTOR PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Unit 1. Energy bands and charge carriers in semiconductors (15)

Bonding forces and energy bands, direct and indirect band gap semiconductors, variation of energy bands with alloy composition, effective mass, electrons and holes in quantum wells, the Fermi level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, electrical conductivity and mobility, high field effects.

Unit 2. Excess carriers in semiconductors (15)

Optical absorption, direct recombination of electrons and holes, indirect recombination, trapping, steady state carrier generation, quasi Fermi levels, diffusion process of carriers, diffusion and drift of carriers, diffusion and recombination: the continuity equation, steady state carrier injection, diffusion length, the Haynes-Shockley experiment.

Unit 3. Dynamics of charge carriers and lattice, and Semiconductor Interfaces (15)

Electrons in a periodic potential, group velocity of electrons, inverse effective mass tensor, force equation, dynamics of electrons and holes, effective mass theory of impurities, the vibrational specific heat, thermal expansion, thermal conductivity. Schottky barriers, rectifying contacts, ohmic contacts, surface and interface states and their effects on barrier height, acceptor and donor surface states, Fermi level pinning

Unit 4. Semiconductor crystal growth process (15)

Nucleation and growth theory, atomic bonding, formation energy of clusters, supersaturation, supercooling and volume energy, stability of small nuclei, the formation energies of liquid nuclei and crystalline nuclei, nucleation rates, the growth of crystal surfaces, growth of bulk semiconductors by zone melting and zone refining, Czochralski and liquid encapsulation techniques, growth of epitaxial layers by LPE, VPE and MBE techniques**.**

Reference Books

1. Physics of Semiconductor Devices by Dilip K. Roy, Univ. Press (India) Pvt. Ltd., 1992.
2. Physics of Semiconductor Devices by S.M. Sze
3. Solid state electronic devices by B. G. Streetman.
4. Semiconductors by R. A. Smith, Cambridge Univ. Press.
5. Solid state electronics by Wang, Mc. Graw Hill.
6. Crystal Growth by B. R. Pamplin (ed.)
7. Growth of Single Crystal by R. A. Laudise.
8. Growth of crystals from solutions by J. C. Brices
9. Solid State and Semiconductor Physics by M.C. Kelvey.
10. Modern techniques in metallography – D.G. Brandon, Butterworths (1966)

M.SC-II, SEME. III, PHYSICS (Nano Physics,Solid State)

HCT - 3.2: ATOMIC and MOLECULAR PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Unit-I Atomic structure and Atomic Spectra (20)

Revision of hydrogen atom (wave functions, orbital and spin angular momentum, Quantum states of an electron in an atom, magnetic dipole moment, Electron spin, spin-orbit interaction, fine structure, spectroscopic terms). Origin of spectral lines, selection rules, Stern Gerlach experiment, some features of one-electron spectra. Relativistic corrections for energy levels of hydrogen atom, Multi-electron atoms: Exchange symmetry of wave functions, Pauli`s exclusion principle, electron configuration, Hund's rule etc. L-S coupling, J-J coupling.

Unit-II Atoms in an electromagnetic field (10)

Spectral lines, Selection rules, Some features of two-electron spectra, fine structure spectra, hyperfine structure spectra, X-ray spectra, Stark effect, Zeeman effect and Paschen-Back effect

Unit-III Molecular Structure and Molecular Spectra (20)

Covalent, ionic and van der Waal bonding, Valence bond and molecular orbital approach for molecular bonding and electronic structure of homonuclear diatomic molecules, pairing and valency, heteronuclear diatomic molecules, hybridization, ionic bonding, electro-negativity, electron affinity. Electronic structure of polyatomic molecules: hybrid orbitals, bonding in hydrocarbons.

Rotational levels in diatomic and polyatomic molecules: Born – Oppenheimer approximation, Rigid and non-rigid rotation, selection rules. Vibrational levels in diatomic and polyatomic molecules: Morse oscillator model for vibrational levels. Vibration spectrum of diatomic molecule, vibration-rotation spectra (P, Q, R branches). Electronic spectra of diatomic molecules: Frank-Condon principle.

Unit-IV Atomic and molecular spectroscopic methods (10)

Atomic and Molecular Polarizability, Molecular vibrations and group theoretical selection rules for infra-red and Raman transitions, Infra-red spectroscopy and Raman spectroscopy for vibrational level determination. Microwave spectroscopy and Rotational Raman spectroscopy for rotational level determination, Electronic spectroscopy for molecular structure determination. Nuclear Magnetic resonance and Electron spin resonance

Text Book: (Unit-I &II)

1. *Quantum Physics,* Robert Eisberg and Robert Resnick, (John Wiley and Sons).

Reference Books: (Unit-I &II)

1. *Introduction to Atomic Spectra,* H. E. White, (McGraw Hill International Ed.)

2. *Perspectives of Modern Physics,* Arthur Beiser, (McGraw Hill International Ed.)

3. Physics of Atoms and Molecules, B.H. Bransden and C.J. Joachain (Pearson).

4. The Physics of Atoms and Quanta Introduction to Experiments and Theory

   Authors: Haken, Hermann, Wolf, Hans Christoph

Text Book: (Unit-III & IV)

1. Molecular Spectra and Molecular Structure, Gerhard Herzberg, (D. Van Nostrand Company, Inc.)

Reference Books: (Unit-III & IV)

1. *Molecular Spectra and Molecular Spectroscopy* (Vol. 1), G. Herzberg

2. *Fundamentals of Molecular Spectroscopy,* C. N. Banwell and E. M. McCash, (Tata, McGrawHill Publishing Company Limited)

3. Molecular Spectroscopy – J.M. Brown, Oxford University Press (1998).

4. Modern Spectroscopy, J.M. Hollas (John Wiley).

5. Molecular Quantum Mechanics, P.W. Atkins and R. Freidman (Oxford University Press)

6. Quantum Chemistry, I. N. Levine (Wiley).

M.Sc-II, SEME. III, PHYSICS (Nano Physics,Solid State)
SCT– 3.1 (MS): DIELECTRIC AND FERROELECTRIC PROPERTIES OF MATERIALS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction (10)

Maxwells equations, Amperes law, Faradays law, Gauss law in presence of dielectric, Electric field, Electric flux density, Polarization, Permittivity, electric susceptibility, Dipole moment , Polar and non-polar dielectrics.

Unit II: Electric Polarization and Relaxation (20)

Fundamentals: Force acting on the boundary between two different dielectric materials, Force elongating a dielectric fluid, Dielectrophoretic force, Electrostriction force, Electrostatic induction , Electric polarization and relaxation in static electric fields, Vacuum space, Conducting materials.

Dielectric Materials and its Polarization: Mechanism of electric polarization, Electronic polarization, Classical and Quantum Mechanical Approach, Atomic or Ionic Polarization, Orientational polarization, Polarizability, Spontaneous polarization, Space charge polarization, Hopping polarization, Interfacial polarization, Classification of dielectric materials, Non-ferroelectric and ferro-electric materials, Internal fields, Local fields for Non-dipolar materials, Clausius-Mosotti Equation.

Dielectrics in AC field: Lorentz - Lorenz equation, Reaction Field for dipolar materials, Electric polarization and relaxation in time -varying electric fields, Time domain approach and the frequency - domain approach, Complex permittivity, Time dependent electric polarization, Kramers - Kronig equations, Debye equations, Absorption, and Dispersion for dynamic polarizations, Effects of the local field, Effects of DC conductivity, Cole - Cole plot, Temperature dependence of complex permittivity, Field dependence of complex permittivity of ferroelectric materials, Insulating materials, Dielectric relaxation phenomena.

Unit III: Optical and Electro-Optic Processes (10)

Modulation of light, Double refraction and birefringence, Quarter - Wave plate, Electro - Optic effects: Linear Electro – Optic effect, Photorefractive effect, Magneto - Optic effect, Faraday effect, Voigt effect, Acousto-Optic effect.

Unit IV: Ferroelectrics, Piezoelectrics and Pyroelectrics (20)

Ferroelectrics: Ferroelectric phenomena, Representative crystal, types of ferroelectrics: Properties of Rochelle salt, $BaTiO_3$, Theory of ferroelectric displacive transitions, Thermodynamic theory, Ferroelectric and antiferroelectric transition, Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, Applications of ferroelectric materials

Piezoelectrics: Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials and their applications.

Pyroelectrics: Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, Pyroelectric and thermally sensitive materials, NTC and PTC materials, Applications of pyroelectric materials.

References Books:

1. Kwan Chi Kao and F. R. de Boer; Dielectric Phenomena in Solids, Elsevier Academic Press (2004).
2. J. P. Srivastava, Elements of Solid State Physics, 2nd Edi Prentice – Hall of India(P) Ltd. (2007)
3. Charles Kittle; Introduction to Solid State Physics, 7th Edition, John Wiley & Sons, (1996).
4. Saxena, Gupta, Saxena; Fundamentals of Solid State Physics, Pragati Prakashan, (2012).
5. A. J. Dekkar; Solid State Physics, 1st Ed. Macmillan (2000).
6. M.A.Wahab; Solid State Physics: Structure and Properties of Materials, Alpha Science International (2005)
7. S.O. Pillai; Solid State Physics, 6th Ed., New Age International (p) Ltd publishers, (2005)
8. Neil W. Ashcroft, N. David Mermin, Solid State Physics; Saunders College, (1976).

M.Sc-II, SEME. III, PHYSICS (Nano Physics,Solid State)
SCT– 3.2 (MS): MATERIAL PROCESSING
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I : Vacuum Technology (12)

Principles of vacuum pump – principle of different vacuum pumps : roots pump, rotary, diffusion turbo molecular pump, cryogenic-pump, ion pump, ti-sub limitation pump, importance of measurement of vacuum, Concept of different gauges, bayet - albert gauge, pirani, penning, pressure control.

Unit II: Physical Vapor Deposition & CVD Techniques (12)

Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, laser ablation, laser pyrolysis, molecular beam epitaxy, electro deposition.

Chemical Vapor Deposition Techniques (12)

Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types boundaries and flow, Different kinds of CVD techniques: Atmospheric pressure CVD (APCVD) – Low pressure CVD (LPCVD) – Plasma enhanced chemical vapor deposition (PECVD) or –The HiPCO method – Photo-enhanced chemical vapor deposition (PHCVD) – LCVD Laser –Induced CVD, Metallorganic CVD (MOCVD), Thermally activated CVD, Spray pyrolysis,etc.

Unit III : Electrical Discharges used in Thin Film Deposition(10) Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion plating, oxidizing and Nitriding, Atommic layer deposition (ALD), Importance of ALD technique, Atomic layer growth.

Unit IV : Conditions for the Formation of Thin Films (12)

Environment for thin film deposition,deposition parameters and their effects on film growth, formation for thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), capillarity theory, microstructure in thin films, adhesion, properties of thin films, Mechanical ,Electrical, and optical properties of thin films, few applications of thin films in various fields, Quartz crystal thickness for measurement of film thickness.

Unit V :Adsorption And Diffusion in Thin Films (12)

Physisorption – Chemisorption –Work function changes induced by induced by adsorbates – Two dimensional phase transititions in adsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion – Grain Boundary Diffusion –Thin Film Diffusion Couples –Inter Diffusion –Electromigration in thin films –Diffusion during film growth, Stress in Thin Films.

Reference Books:

1. Hand book of Thin films Technology: L I Maissel and R Clang.
2. Thin film Phenomena: K L Chopra.
3. Physics of thin films,vol.12,Ed George Hass and others.
4. Vacuum deposition of thin films – L Holland.
5. Milton Ohring,Materials Science of Thin films Published by Academic Press Limited (1991)
6. L.B.Freund and S.Suresh, Thin Film Materials,(2003)
7. Hans Luth, Solid Surfaces, Interfaces and Thin Films' 4th edition,Springer Publishers (2010)
8. HaraldIbach, Physics of Surfaces and Interfaces, Springer Publishers (2006).

AMY R L Banshow

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
SCT –3.3: MATERIALS CHARACTERIZATION
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: (12)

Introduction to the Common Concepts in Materials Characterization:

Measurements of Mass and Density, Different kinds of Balances. Roughness, Porosity and Surface area measurement. Microscopic tools and necessity, Spectroscopic tools and necessity, Resonance techniques and necessity, Surface properties and the necessary tools, Understanding Crystallinity, Thermal properties and thermal analysis like thermal conductivity ,specific heat, melting temperature and other phase transitions using TG,DTG,DTA etc. Methods of Temperature measurements, Hardness of material measurements and associated Physics, Materials aspects: particles, bulk, thin and thick films, gel, suspension and rheological properties. General behavior of metals, ceramics, semiconductors, polymers and tools required to characterize them, Methods of Sample preparation: polishing, grinding, sectioning, annealing, sintering, etching.

Errors in measurements, Analysis of errors, Curve Fitting. Standard Distribution functions, International Standards: ASTM and other standards

UnitII : Vacuum Techniques (12)

Fundamental concept of vacuum, units of measurements, Kinetic theory of gases. practical aspects of vacuum technology: vapor pressure, out-gassing, seals, pumping speeds, conductance, through puts. Order of vacuum and necessity during the material characterization

Vacuum pumps: Mechanical pumps ,Water pumps, Rotary oil pumps, Roots pumps,

Unit III: Structural analysis of materials by X-ray diffraction analysis (12)

Introduction to generation and detection of X-rays, Crystalline, polycrystalline ,nano-crystalline and amorphous solids. Laue method for single crystal structural analysis. Powder diffraction methods, Analysis of cubic structures, introduction to crystal symmetry and crystal structure, Factors affecting the intensity in Powder XRD, Structure factor , few examples of NaCl, KCl, KBr etc.. Different X-Ray Cameras and geometries.

Unit IV: Characterization of Electrical Properties (12)

Electrical transport in metals, semiconductors and insulators and difficulty in measurements, Bulk conductivity , practical aspects of methods , Surface conductivity measurements ,Four probe method of conductivity measurement,Van der Pauw measurement for an arbitrary shape ,Practical aspects and problems, Non contact mode of conductivity measurement.Microwave techniques, Hall effect in semiconductors, Hall mobility measurements. Measurement of Introduction to Deep Level Transient Spectroscopy (DLTS).Electrical conductivity with temperature ,Defects in semiconductors and their measurements .Estimation of mobility band gap in semiconductors, Photoconductivity,

Unit V: Characterization of Optical Properties (12)

Introduction to electromagnetic (EM) spectrum Energy wavelength and frequencies of EM radiations. Interaction of EM radiations with matter in different regions of EM spectral regions. Absorption. Reflection and Transmission in materials, Beer Lambert Law. Laboratory sources of EM radiations, Basic definition of spectrometer .and its components. Vibrational spectroscopy for determining the molecular bonds and structure, UV-Visible absorption spectroscopy, Its use to determine the Band gap of semiconductors ,Refractive index of thin films, Factors affecting the absorption. Photoluminescence (PL) spectroscopy for understanding the band gap solids.

Reference Books:

1)“Charecterization of Materials”, Elton N.Kaufmann,Vol I & II ,Wiley Interscience,2003.

2)Elements of X-Ray Diffraction”,CulityB.D.,Addison Wesley Publishing Company.

3)“Fundamentals of Molecular Spectroscopy” ,C.N.Banwell,Tata McGraw–Hill Publishing Company Limited

4)“Instrumental Methods of Analysis” ,H.H.Willard, L.L.Merritt, J.A.Dean, F.A.Settle, CBS Publishers & Distributors, Delhi.

5)“X-Ray Diffraction”, C.Suryanarayana and Grant Norton,SpringerScience+Business Media, LLC

6) Absorption Spectroscopy, Bauman R.P., Wiley .New York

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
OET - 3.1: ENERGY HARVESTING DEVICES

Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit -1: Solar Cells (15)

Photovoltaic effect, Solar cell characterization, Types of Solar cells, Solid state solar cells Silicon solar cell, CdTe based solar cells, CdS/Cu_2S solar cells, $CuInSe_2$ based solar cells, Metal-semiconductor solar cells, photoelectrochemical and photo electrolysis cells, Solar cells based on thin film heterojunctions, Ultra thin absorber solar cells, Nanostructured solar cells, Dye sensitised solar cells: basic concepts, working and materials. Organic Solar cells: basic concepts, working and materials.

Unit -2: Super Capacitors (15)

Comparison of battery and super capacitors, Super capacitor characterization, Types of super capacitors, double layer and pseudo capacitance, hybrid super capacitors, Recent status of carbon, RuO_2 and polyaniline based super capacitors, different methods for preparation of cathodic and anodic electrode materials, Fabrication of super capacitors with examples, Applications of supercapacitors

Unit -3: Fuel Cells (15)

Comparison between fuel cells and batteries, fuel cell characterizations, Types of fuel

cells: Metal oxide, proton exchange membrane, Phosphoric acid, Solid oxide fuel

cells, working of fuel cells, Materials for fuel cells, applications of fuel cells

Unit -4: Piezoelectrics (15)

Piezoelectric Energy Harvesting: Energy harvesting basis, case study
Piezoelectric Materials: Piezoelectric polycrystalline ceramics,Piezoelectric Single Crystal Materials, Piezoelectric and Electrostrictive Polymers, Piezoelectric Thin Films.
Piezoelectric transducers, Mechanical energy harvester using Laser Micromachining, Mechanical energy harvester using PlezoelectricFibers, Piezoelectric Microcantilevers, Energy harvesting circuits, Multimadal energy harvesting, Mangetoelectric composites,
Introduction to Piezoelectric bulk Power generators, Piezoelectric Micro Power Generators, Conversion efficiency, Power storage circuits

Reference Books

1. Semiconductor Sensors, S M Sze, A Wiley- Interscience Publication,

John Wiley and Sons, NY1994

2. Electrochemical Supercapacitors, B E Conway, Kluwer Academic/ Plenum publishers, NY 1999.

3. C. N. R. Rao and Claudy Rayan Serrao, J. Mater. Chem., 2007, 17, 4931–4938

4. Solar Cells by Martin Green.

5. Photoelectrochemical Solar Cells by S. Chandra, Gordon &Breach Science Publisher, UK

6. Energy Harvesting Technologies, ShashankPriya, Daniel J. Inman Springer

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
OET - 3.2: NUCLEAR RADIATION & EFFECTS

Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

Unit-1: Interaction of Charged Particles with Matter (10)

Introduction to Charged Particles, Theory and general features for charged particles - the Bethe-Bloch equation, Photon interactions - photoelectric effect, Compton scattering, Pair production, Neutron scattering and absorption, Attenuation and shielding. **(J S Lilley),** Interaction of Heavy Charged Particles, Interaction of Fast Electrons, Interaction of Gamma Rays, Interaction of Neutrons **(Glenn F Knoll)**

Unit-2: Nuclear Radiation Units (08)

The Roentgen and the Rad, Photon Flux and Radiation Dose, Dose rate and radioactive source strength, Radiation dose from internal source, The Rem, Gray, Rad to Gray Conversion, Fluence **(Samuel Glasstone)**

Unit-3: Radiation effects on Semiconductor Materials (12)

Basic Radiation Damage Mechanisms in Semiconductor Materials and Devices:Introduction. Fundamental Damage Mechanisms: Ionization Damage, Displacement Damage. Impact ofRadiation Damage on Device Performance: Spectroscopic Study of Microscopic Radiation Damage: Electron Paramagnetic Resonance (EPR), Deep Level Transient Spectroscopy (DLTS), Photo-luminescence Spectroscopy (PL)

Displacement Damage in Group IV Semiconductor Materials: Introduction, Displacement Damage in Silicon: Radiation Defects in Silicon, Impact of Radiation Defects on Silicon Devices, Substrate and Device Hardening, Displacement Damage in Germanium: Potential Applications of Ge, Cryogenic Irradiation of Ge, Room Temperature Irradiation of Ge, Impact Radiation Damage on Ge Materials and Device Properties, Displacement Damage in SiGe Alloys: SiGe Material Properties and Applications, Radiation Damage in SiGe, Processing-Induced Radiation Damage in SiGe, Radiation Damage in SiGe Devices **(C. Claeys)**

Unit-4 : Biological Effects of Radiation (15)

Introduction, Somatic effects of radiation, genetic effects of radiation, The radiation back ground, Radiation dose from nuclear power operations, estimates of biological consequences. **Radiation Hazards:** Health-physics activities, Effects of different types of radiation, External and internal radiation sources, Protection from radiation hazards. **(Samuel Glasstone)**

Unit-5: Useful Applications of Nuclear Radiation: Nuclear Medicine (15)

Production of various radioactive isotopes, application of the isotope in therapeutic process like gamma ray therapy, boron neutron capture therapy, heavy ion therapy applications of radioisotopes in imaging process like, gamma camera, positron emission tomography and magnetic resonance imaging are discussed. **(Fieldmen &Soete)**

TEXT BOOKS

1. Gnell F Knoll, Radiation Detectibn and Measurement, Third Edition, John Willey, 2000

2. John S Lilley, Nuclear Physics Principles and Applications, Willey, 2001

3. C. Claeys E. SimoenRadiation Effects in Advanced Semiconductor Materials and Devices, Springer

4. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, D. Van Nostrand Company, INC. 1967.

5. De Soete, D. R. Gijbels and J. Hoste, Neutron Activation Analysis. John Wiley and Sons: New York, NY. (1972).

6. L. C. Feldmen and J. W. Mayer, Fundamentals of surface and thin films analysis, North-Holland, Elsevier, 1986.

REFERENCE BOOKS

1. Robley D Evans, The Atomic Nucleus, TMH, 1955

2. L. Cohen, Concepts of Nuclear Physics, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.

M.SC-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
HCT -4.1: SEMICONDUCTOR DEVICES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: MIS Structure and MOS FETs (15)

Schottky diode, MIS structures, basic equations in flat band conditions, MIS capacitances, current flow mechanisms in MS junction and MIS junction, depletion and enhancement type MOS FETS, capacitances in MOS FETs, quantitative analysis of I - V characteristics, thresholds in MOSFETS, charge trapping and flat band voltage, study of CMOS devices.

Unit II: Power Devices (15)

Power diodes, ratings, reverses recovery characteristics, fast recovery diodes, Power transistors,Switching characteristics, construction of SCR, two transistors analogy, I - V characteristics, gate trigger characteristics, turn on and turn - off times, losses, reverse recovery characteristics, SCR ratings, dv/dt and di/dt characteristics, thyrister types, construction and characteristics of DIACs and TRIACs, static induction thyristors, , light activatedthyristors, Gate turn off thyristors (GTO), MOS controlled thyristors, programmable Unijunction transistors, Silicon Unidirectional switch (SUS) , IGBT

Unit III: Charge Coupled and Transferred Electron (15)

Charge storage, surface potential under depletion, construction of basic two and three phase of CCD, mechanism of charge transfer, Oxide Charges, charge trapping and transfer efficiency, dark current, buried channel CCD, application of CCD, Transferred Electron Effect, NDR (Negative differential resistivity of voltage and current controlled devices), formation of gunn domains, uniform and accumulation layer, operation modes, transistors and quenched diodes, layers and modes of operation, LSA mode of operation, frequency responses and overall device performance of Gunn devices.

Unit IV: Optoelectronic and Advanced Solid State Devices (15)

Light emitting diodes, Performance of LEDs, emission spectra, visible and IR LEDs, semiconductor LASER: p-n junction lasers, heterojunction lasers, materials for semiconductor LASER, threshold current density, effect of temp. Quantum well hetero structures,

Detectors:photoconductors, photocurrent gain and detectivity, photodiodetypes : p-n junction, p-i-n, avalanche characteristics, quantum efficiency, response speed, noise and optical absorption coefficient, efficiency, Solar cells – current voltage characteristics

Reference Book/Text Book:

1. D.A. Roustan: Bipolar Semiconductor Devices.
2. Mauro Zambuto: Semiconductor Devices.
3. D. Nagchoudhari: Semiconductor Devices.

4. Karl Hess: Advanced theory of semiconductors devices.
5. S. M. Sze: Physics of Semiconductor Devices 2nd edition..
6. A Dir - Bar - Lev: Semiconductor and Electronic Devices.
7. M. H. Rashid: Power Electronics.
8. P. C. Sen: Power electronics
9. B. G. Streetman and S. Banergee : Solid state Electronic Devices

M.SC-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
HCT - 4.2: NUCLEAR AND PARTICLE PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit 1. Properties of Nucleus & Nuclear Forces (15)

Shape and Size, mass, spin and parity, masses and relative abundances, binding energy & nuclear stability, nuclear compositions, quantum properties of nucleon states, Radioactivity; Laws of radioactivity, radioactive dating, radioactive series, theory of alpha, beta & gamma decays and their properties. Nuclear forces: Properties of nuclear forces, two nucleon systems deuteron with potentials, n-p and p-p/n-n interactions at different energies, Yukawa's hypothesis, Meson theory of nuclear force.

Unit 2. Nuclear models: **(15)**

Fermi gas model, liquid drop model and Bethe-Weizsacker formula, their applications; shell model and shell structure , extreme single particle shell model with potentials – square well, harmonic oscillator, spin orbit interaction, Magic numbers, Predictions of the shell model; collective nuclear model;

superconductivity model (ideas only).

Unit 3. Nuclear reactions: (15)

Types of nuclear reactions, conservation laws, Nuclear reaction kinematics, nuclear scattering cross section determinations, compound nucleus disintegration, Breit Wigner dispersion formula (one level), direct reactions, nuclear transmutation reactions, nuclear fission and fusion,

Unit 4. Particle Physics & Cosmic rays: (15)

Broad classification of elementary particles and particle interactions in nature, conservation laws, symmetry classifications of elementary particles- Gell-Mann-Nishijima scheme,CPT conservation, Quark hypothesis & Quantum chromodynamics (ideas only); Cosmic rays: origin of cosmic rays, nature of primary cosmic rays and its energy distribution, its geomagnetic ,latitude effect, east-west asymmetry, origin of secondary rays, collision with electrons,. Particle accelerators and detectors: linear accelerators, cyclotron, synchrotron, colliding beam accelerators (LHC), gas-filled counters, scintillation detectors, semiconductor detectors.

Recommended Books:

1. Atomic and Nuclear Physics: Gopalakrishnan (MacMillan)

2. Concepts of Modern Physics: A.Beiser.

3. Concepts of Nuclear Physics: Bernard L Cohen.

4. Nuclear Physics: D C Tayal.

5. Subatomic Physics, Frauenfelder and Henley. (Prentice-Hall)

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
HCT - 4.3: PHYSICS OF NANO MATERIALS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction (15)

Background of Nanoscience and Nanotechnology, Definition of Nanoscience and Nanotechnology, Possible Applications of Nanotechnology, Top-down and Bottom-up approach (Brief).

Band Structure and Density of States at Nanoscale: Introduction, Energy Bands, Density of States at Low - dimensional Structures, Quantum confinement – semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement, quantum confinement effect, dielectric quantum confinement, effective mass approximation, core-shell quantum dots.

Unit II: Properties of Nanomaterials (15)

Optical properties: Absorption, transmission, Beer-Lamberts law (derivation), Photoluminscence, Fluorescence, Phosphorescence, Cathodoluminscence, Electroluminescence, Surface Plasmon resonance (SPR), effect of size of nanoparticles (metal, semiconductor) on absorption and SPR spectra.

Electrical transport: Electrical Conduction in Metals, Classical Theory - The Drude Model Quantum Theory - The Free Electron Model Conduction in Insulators/Ionic Crystals, Electron Transport in Semiconductors, Various Conduction Mechanisms in 3D (Bulk), 2D(Thin Film) and Low – dimensional Systems**,** Thermionic Emission Field – enhanced Thermionic Emission (Schottky Effect), Field - assisted Thermionic Emission from Traps (Poole - Frenkel Effect), Hopping Conduction, Polaron Conduction.

Unit III: Growth Techniques and Characterization Tools of Nanomaterials (20)

Growth techniques: Introduction, Top - down vs. Bottom - up Technique, Lithographic Process and its limitations , Nonlithorgraphic Techniques ,Plasma Arc Discharge Sputtering ,Evaporation, Chemical Vapour Deposition ,Pulsed Laser Deposition ,Molecular Beam Epitaxy, Sol - Gel Technique , Electrodeposition , Different chemical routes, Other Processes.

Characterization Tools of Nanomaterials: Scanning Probe Microscopy (SPM): Introduction, Basic Principles of SPM Techniques, The Details of scanning Tunneling Mocroscope (STM), General Concept and Definite Characteristics of AFM, Scanned - Proximity Probe Microscopes Laser Beam Deflection, AFM Cantilevers ,Piezoceramics, Feedback Loop Alternative Imaging Modes. Electron Microscopy: Introduction, Resolution vs. Magnification

Scanning Electron Microscope SEM Techniques, Electron Gun Specimen Interactions Environmental SEM (FESEM), Transmission Electron Microscope, High Resolution TEM Contrast Transfer Function. Near-field scanning optical microscopy (SNOM/NSOM), UV-Vis single and dual beam spectrophotometer, photoluminescence spectrometer, X-ray diffractometer. Surface area and Pore size measurements (BET Analysis)

Unit IV: Some Special Topics in Nanotechnology (10)

Introduction ,The Era of New Nanostructure of Carbon Buckminsterfullerene, Carbon Nanotubes, Nanodiamond, BN Nanotubes Nanoelectronics ,Single Electron Transistor, Molecular Machine, Nano-biometrics.

Reference Books:

1) Introduction to Nanoscience and Nanotechnology: K.K. Chattopadhyay and A.N. Banerjee, PHI Publisher
2) Nanoscience and Technology: V. S. Murlidharan, A. Subramanum.
3) Nanotubes and Nanofibers:YuryGogotsi
4) A Handbook of Nanotechnology : A. G. Brecket
5) Instrumentations and Nanostructures: A. S. Bhatia
6) Nanotechnology: Nanostructures and Nanomaterials - M. B. Rao
7) Nanotechnology-Principles and practices - S. K. Kulkurni (Capital Publication Company)

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)

SCT - 4.1: ADVANCED TECHNIQUES OF MATERIALS CHARACTERIZATION

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Unit I: Microscopic Techniques: (10)

Optical Microscopy and limitations: Principle of Diffraction of light, Airy Disc, Resolution and magnification; Rayleigh Criteria, Numerical aperture, Major lens defects. Different kinds of optical microscopes (Bright field, Stereo, Phase contrast, Differential Interference Contrast, Fluorescence, Confocal, Polarizing light microscope)

Unit-II: Electron Microscopy (20)

Limitations of Light microscopy and advantages of electron microscopy. Wavelength of electrons, Theoretical Resolving power, Source of electron emission .Electron Focusing, Effect of magnetic fields, Electrostatic and magnetic focusing, Optical Column, Magnetic lenses. Vacuum requirements. Schematic of complete SEM

Scanning Electron Microscopy (SEM): Interaction of electrons with matter. Secondary electron emission (SEE), Yield of SEE, Universal yield curve, Beam scanning and Magnification in SEM, Secondary electrons Detector, Back scattered electrons detector. Electronics. Image analysis. Size histogram. Sample preparation.

Transmission Electron Microscopy(TEM) : Principle of operation, Lens systems, Schematic of TEM ,Apertures, Bright Field Image, Dark Field Image ,.Electron Diffraction, Bragg's Condition, Selective Area Electron Diffraction (SEAD), Image analysis. Sample preparation

Scanning Tunneling Microscopy

Historical perspective, Electron tunneling ,Principle of STM imaging , STM image interpretation ,STM implementation in instrument , Piezoelectric drive, Tip preparation, Vibration isolation, Data acquisition and analysis, Application of STM , high resolution imaging of surfaces, Spectroscopy, Lithography, Current fluctuation, Limitation of STM and solution,

Atomic Force Microscopy: Principle and equations of force curves, Contact and Non contact modes, Amplitude modulation and Frequency modulation, Force versus distance curve, Experimental details of AFM, Practical applications.

Unit III: X-Ray Photoelectron Spectroscopy (15)

Definition of surface, Different Probes for Surface-characterization. Necessity of Ultra High Vacuum, Photoelecton Emission, Introduction and Basic Theory, Historical Perspective, Instrumentation, Vacuum System. Energy analyzers, X-Ray Source, Electron Energy Analyzer. Sample Selection and Preparation , Sample Charging .X-Ray Beam Effects., Spectral Analysis ,Core Level Splitting .,Linewidths. Elemental Analysis: Qualitative and Quantitative, Secondary Structure, Angle-Resolved XPS, Depth profiling.

Unit IV. Raman and Resonance spectroscopy: (15)

Raman Effect and Raman spectroscopy: Classical and Quantum theory of Raman Effect, Rotational and vibrational structure of Raman spectrum - pure rotational Raman spectra of diatomic molecules, vibration rotation Raman spectrum of diatomic molecule, intensity alterations, Application of Raman spectroscopy.

Resonance Technique: NMR – nuclear spin magnetic moment, interaction of nuclear magnet with external field. Quantum description of N.M.R., NMR spectrometer, Chemical shift, Spin–spin interaction, Applications of NMR spectroscopy.

Reference Books:

1) Handbook of Applied Solid State Spectroscopy, D. R. Vij, Springer

2) Phtoelectron and Auger Spectroscopy, T.A.Carlson, Plenum Press , 1975

3) Practical Guide to Surface Science and Spectroscopy,Yip-WahChung,Academic Press

4) Fundamental of Molecular Spectroscopy, C.N.Banwell, TataMc-Graw Hill.

M.Sc-II, SEME. IV, PHYSICS (Nano Physics,Solid State)
SCT - 4.2: MAGNETIC MATERIALS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction (15)

Measurement of Field Strength, Hall Effect, Electronic Integrator or Flux meter, Magnetic Measurements in Closed Circuits, Demegnetizing Fields, Magnetic Shielding, Demagnetizing Factors, Magnetic Measurements in Open Circuits, Instruments for Measuring Magnetization, Vibrating - Sample Magnetometer, Altering (Field) Gradient Magnetometer - AFGM or AGM, (also called Vibrating Reed Magnetometer), Magnetic Circuits and Parameters, Permanent Magnet Materials, Susceptibility Measurements.

Unit II: Magnetism in Materials (20)

Diamagnetism and Para magnetism:

Introduction, Magnetic Moments of Electrons, Magnetic Moments of Atoms, Theory of Diamagnetism, Diamagnetic Substances, Classical Theory of Para magnetism, Quantum Theory of Para magnetism, Gyro magnetic Effect, Magnetic Resonance

Ferromagnetism: Introduction, Molecular Field Theory, Exchange Forces, Band Theory, Ferromagnetic Alloys, Theories of Ferromagnetism

Antiferromagnetism: Introduction, Molecular Field Theory, Above $T_{N,}$ Below $T_{N,}$ Comparison with Experiment, Neutron Diffraction, Antiferromagnetic, Ferromagnetic, Rare Earths , Antiferromagnetic Alloys.

Ferrimagnetism: Introduction, Structure of Cubic Ferrites, Saturation Magnetization, Molecular Field Theory, Above Tc, Below Tc, General Conclusions, Hexagonal Ferrites, Other Ferromagnetic Substances, y - $Fe_2O_{3,}$ Garnets, Alloys.

Unit III: Magnetic Anisotropy, Magnetostriction and the Effects of stress (15)

Magnetic Anisotropy: Introduction, Anisotropy in Cubic Crystals, Anisotropy in Hexagonal Crystals, Physical Origin of Crystal Anisotropy, Anisotropy Measurement, Torque Curves, Torque Magnetometers, Anisotropy Measurement (from Magnetization Curves), Fitted Magnetization Curve, Anisotropy Constants, Polycrystalline Materials

Magnetostriction: Introduction, Magnetostriction of Single Crystals, Cubic Crystals, Magnetostriction of Polycrystals, Physical Origin of Magnetostriction, Form Effect, Effect of Stress on Magnetic Properties, Effect of Stress on Magnetostriction, Applications of Magnetostriction, ΔE Effect, Magnetoresistance.

Unit IV: Domains and the Magnetization Process (10)

Introduction, Domain Wall Structure, Neel Walls, Magnetostatic Energy and Domain Structure, Uniaxial Crystals, Cubic Crystals, Domain Wall Motion, Magnetization in Low Fields, Magnetization in High Fields, Shapes of Hysteresis Loops.

Reference Books:

1. K. H. J. Buschow& F. R. de Boer: Physics of Magnetism and Magnetic Materials.
2. C. Kittle: Introduction to Solid State Physics.
3. Azoroff : Introduction to Solids.
4. Saxena, Gupta, Saxena: Fundamentals of Solid-state Physics.
5. R. L. Singhal: Solid State Physics.
6. V. Raghavan: Materials Science and Engineering.
7. A. J. Dekkar: Solid-state Physics.

M.SC-, PHYSICS (Nano Physics,Solid State)

Choice Based Credit System (CBCS)

(w. e. f. June 2020-2021)

Practical List

HCP 1.1/1.2/1.3

1) Determination Band gap of Ge Diode.
2) Crystal Structure FCC type.
3) Temp. Variation of Breakdown voltage of zerer diode.
4) Temperature Transducer (Thermister).
5) P.N. Junction capacitance.
6) LVDT.
7) Photovoltaic cell.
8) Hall Effect.
9) CC with CC Amplifier.
10) DC Amplifier.
11) Voltage Regulator
12) Astablenultivibrator (using IC741Op Amp)
13) Op-Amp Phase Lead Circuit.
14) Op-Amp Phase Lag circuit.
15) Verificaiton of De Morgans theorem.
16) Wein Bridge Oscillator.
17) Op-Amp Phase shift Oscillator.
18) Negative feedback Amplifier.
19) D.T.L. gates.
20) Study of filters.
21) Transistor Biasing.
22) CE amplifier Desing.
23) FET characteristics and Designing of Amplifier.
24) Divide by 2 Divide by 5 & Divide by 10 counter using IC-7490.

SCP 1.1/1.2

1) Op-Amp (Adder, Subtractor, Integratorc, Differentiator).
2) Op-Amp I to V, V to I converter.
3) Voltage source.
4) Constant current source (floating load).
5) Constant current source (Grounded load).
6) Variable duty cycle MV using Op-Amp.

HCP 2.1/2.2

1) Wave form generator (square & triangular)
2) Twin T network.
3) Bear Lamberts law
4) Resistivity by four probe method.
5) Strain gauge I.
6) Lattice prarameter&particlesiretestimation.
7) Op-Amp instrumentation amplifier IC324.
8) Characteristics of UJT.
9) Electrodepositon of Mn.
10) Op-Amp. Parameters.

SCP 2.1/2.2

1) Study of thermocouple &thermister.
2) Intensity calculation.
3) Crystal structure I.
4) Crystal structure II.
5) Study of phase diagram.
6) Hall Effect II.

OEP 2.1/2.2

1) Transister Parameters.
2) Op-Amp inverting and non-inverting amplifiers.
3) Monostablemultivibratorvsing IC555.
4) FET charaterishes.
5) Op-Amp Adder.
6) Op-Amp subtractor.
7) First order High pass filter.
8) First order Low pass filter.
9) Determination of optical gap.
10) Determination of optical absorption by materials & hence determination of type of transition.
11) Study of p.n. junction photo voltaic.
12) Characterization of a PV cell in dark & in light & hence determination of junction ideality factor.

HCP 3.1/3.2

1) Susceptibility measurement of $FeCl_3 6H_2O$ solution.
2) Successive Ionic Layer Adsorption and Reaction.
3) Chemical Bath deposition of PbS.
4) Chemical Bath deposition of CdS.
5) Strain gauge II.
6) Optical studies on CdS thin film (α vs λ, determination of E_g and m).
7) LVDT II.
8) Band gap determination using four probe method.
9) Hydroxide co-precipitation of $Ba_{0.8}Sr_{0.2}TiO_3$
10) Electrodeposition of Ni.
11) Ceramic synthesis of PZT.
12) Antocombustionsyrthesis of $Cofe_2O_4$.

SCP 3.1

1) Faraday Effect.
2) Kerr Effect.
3) Pockel Effect.
4) Electrical conductivity measurement and determination of activation energy.
5) Thermoelectric power measurement.
6) Determination of curie temperature.
7) Particle size estimation.

____________________xxxx___________________xxxx_____________________

DBF Dayanand College of Arts & Science,
Department of Physics

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

M. Sc – Physics (Solid State)
Choice Based Credit System
w.e.f June 2019-20

Semester	Code	Title of the Paper	Semester exam			L	T	P	Credits
First		**Hard core**	**Theory**	**IA**	**Total**				
SS	**HCT1.1**	Mathematical Techniques	70	30	100	4		-	4
	HCT1.2	Condensed Matter Physics	70	30	100	4		-	4
	HCT1.3	Analog& Digital Electronics	70	30	100	4		-	4
		Soft Core (Any one)							
	SCT1.1	Classical Mechanics	70	30	100	4		-	4
	SCT1.2	Elements of Material Science	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 1.1	Practical HCP 1.1	35	15	50	-	-	2	6
	HCP1.2	Practical HCP 1.2	35	15	50	-	-	2	
	HCP1.3	Practical HCP 1.3	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP1.1	35	15	50	-	-	2	2
	SCP1.2	Practical SCP1.2	35	15	50	-	-	2	
		Total for first semester	**420**	**180**	**625**				**25**
Second		**Hard core**							
SS	**HCT2.1**	Quantum Mechanics	70	30	100	4		-	4
	HCT2.2	Electrodynamics	70	30	100	4		-	4
		Soft core (Any one)							
	SCT2.1	Statistical Mechanics	70	30	100	4		-	4
	SCT2.2	Analytical Techniques	70	30	100	4		-	
		Open elective (Any one)							
	OET2.1	Fundamentals of Electronics	70	30	100	4		-	4
	OET2.2	Conventional & Non conventional Energy	70	30	100	4		-	
		Tutorial			25		1	-	1
		Practical							
	HCP 2.1	Practical HCP 2.1	35	15	50	-	-	2	4
	HCP2.2	Practical HCP 2.2	35	15	50	-	-	2	
		Soft core (Any one)							
	SCP1.1	Practical SCP2.1	35	15	50	-	-	2	
	SCP1.2	Practical SCP2.2	35	15	50	-	-	2	2
		Open elective (Any one)							
	OEP2.1	Practical OEP2.1	35	15	50	-	-	2	2
	OEP2.2	Practical OEP2.2	35	15	50	-	-	2	
		Total for second semester	**420**	**180**	**625**				**25**

Third		**Hard core**							
SS	**HCT3.1**	Semiconductor Physics	70	30	100	4		-	4
	HCT3.2	Atomic and Molecular Physics	70	30	100	4		-	4
		Soft core (Any one)							
	SCT3.1	Advanced Condensed Matter Physics	70	30	100	4		-	4
	SCT3.2	Experimental Techniques for Physics	70	30	100	4		-	
	SCT3.3	Properties of Solids	70	30	100	4			
		Open elective (Any one)							
	OET3.1	Nanoscience &Technology	70	30	100	4		-	
	OET3.2	Energy Harvesting Devices	70	30	100	4		-	4
		Tutorial			25		1	-	1
		Practical							
	HCP 3.1	Practical HCP 3.1	35	15	50	-	-	2	2
	HCP3.2	Practical HCP 3.2	35	15	50	-	-	2	2
	SCP 3.1	Practical SCP 3.1	35	15	50	-	-	2	2
		Open elective (Any one)							
	OEP3.1	Practical OEP3.1	35	15	50	-	-	2	2
	OEP3.2	Practical OEP3.2	35	15	50	-	-	2	
		Total for third semester	**420**	**180**	**625**				**25**
Four		**Hard core**							
SS	**HCT4.1**	Semiconductor Devices	70	30	100	4		-	4
	HCT4.2	Nuclear and Particle Physics	70	30	100	4		-	4
	HCT 4.3	Thin Film Physics and Technology	70	30	100	4		-	4
		Soft core (Any one)						-	4
	SCT4.1	Materials Characterization Techniques	70	30	100	4		-	
	SCT4.2	Physics of Nano Materials	70	30	100	4		-	
		Tutorial			25		1	-	1
	MP4.3	Major Project	140	60	200	-	-	-	8
		Total for four semester	**420**	**180**	**625**				**25**
	Total								**100**

L = Lecture T = Tutorials P = Practical IA=Internal Assessment
4 Credits of Theory = 4 Hours of teaching per week
2 Credits of Practical = 4 hours per week
HCT = Hard core theory
SCT = Soft core theory
HCP = Hard core practical
SCP = Soft core practical
OET = Open elective theory
OEP = Open elective practical
MP = Major project

MP = Major project

- **140 Marks-University Examinations (Viva Dissertation, Project Progress, evaluation)**
- **60 Marks- Internal Performance Evaluation (20 Marks: Presentations, 20 Marks :Performance & 20 Marks: Attendance)**

M.Sc-II, SEM. III, PHYSICS (Solid State)

HCT - 3.1: SEMICONDUCTOR PHYSICS
Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Energy bands and charge carriers in semiconductors (15)

Bonding forces and energy bands, direct and indirect band gap semiconductors, variation of energy bands with alloy composition, effective mass, electrons and holes in quantum wells, the Fermi level, electron and hole concentrations at equilibrium, temperature dependence of carrier concentrations, electrical conductivity and mobility, high field effects.

Unit 2. Excess carriers in semiconductors (15)

Optical absorption, direct recombination of electrons and holes, indirect recombination, trapping, steady state carrier generation, quasi Fermi levels, diffusion process of carriers, diffusion and drift of carriers, diffusion and recombination: the continuity equation, steady state carrier injection, diffusion length, the Haynes-Shockley experiment.

Unit 3. Dynamics of charge carriers and lattice, and Semiconductor Interfaces (15)

Electrons in a periodic potential, group velocity of electrons, inverse effective mass tensor, force equation, dynamics of electrons and holes, effective mass theory of impurities, the vibrational specific heat, thermal expansion, thermal conductivity. Schottky barriers, rectifying contacts, ohmic contacts, surface and interface states and their effects on barrier height, acceptor and donor surface states, Fermi level pinning

Unit 4. Semiconductor crystal growth process (15)

Nucleation and growth theory, atomic bonding, formation energy of clusters, supersaturation, supercooling and volume energy, stability of small nuclei, the formation energies of liquid nuclei and crystalline nuclei, nucleation rates, the growth of crystal surfaces, growth of bulk semiconductors by zone melting and zone refining, Czochralski and liquid encapsulation techniques, growth of epitaxial layers by LPE, VPE and MBE techniques.

Reference Books

1. Physics of Semiconductor Devices by Dilip K. Roy, Univ. Press (India) Pvt. Ltd., 1992.
2. Physics of Semiconductor Devices by S.M. Sze
3. Solid state electronic devices by B. G. Streetman.
4. Semiconductors by R. A. Smith, Cambridge Univ. Press.
5. Solid state electronics by Wang, Mc. Graw Hill.
6. Crystal Growth by B. R. Pamplin (ed.)
7. Growth of Single Crystal by R. A. Laudise.
8. Growth of crystals from solutions by J. C. Brices
9. Solid State and Semiconductor Physics by M.C. Kelvey.
10. Modern techniques in metallography – D.G. Brandon, Butterworths (1966)

M.Sc-II, SEM. III, PHYSICS (Solid State)

HCT - 3.2: ATOMIC and MOLECULAR PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Atomic Physics: (15)

Vector atom model and quantum numbers, Larmar precession, spectroscopic terms, Lande's g factor, fine structure of hydrogen atom- relativistic correction, spin-orbit interaction, intensity of fine structure lines, Lamb shift, hyperfine structure of spectral lines, determination of nuclear spin, ground state of one-electron and two-electron atoms and their spectra– perturbation theory and variational method, para and ortho states, pauli exclusion principle, Excited states, doubly excite states, Auger effect,resonance. Many electron atoms: Central field approximation, Thomas-Fermi model, Hartee-Fock method and self-consistent field, Hund's rule, L-S and j-j coupling schemes, fine structure of sodium d line, Lande interval rule, the idea of Hartee-Fock equations. The spectra of alkalis using quantum defect theory, selection rules for electronic and magnetic multiple radiations, Oscillator strengths and Thomas Reich-Kuhn sum rule.

Unit 2. Interaction of atoms with Electromagnetic fields: **(15)**

Spectra of alkali and alkaline earths elements -complex spectra - multiplet structure, Zeeman effect, Paschen-Back Effect, Stark effect, hyperfine structure of spectral line, broadening of spectral lines, X-ray spectra.

Unit 3. Molecular Physics: (15)

Born-Oppenheimer approximation, rotation and vibration of diatomic molecules,electronic spin and Hund's cases and nuclear spin, electronic structure of diatomic molecules, structure of polyatomic molecules. Rotational spectra: Intensity of rotational spectra, Isotopic effect of rotational spectra, non-rigid rotator, and vibrational spectra: anharmonic effect, Diatomic Vibrating rotator,Breakdown of Born-Openhemer approximation – interaction of rotational vibration, Electronic spectra,Fortrant diagram. Atomic collisions: Types of collisions, channels, thresholds, cross-sections, potential scattering, general features, Born approximation.

Unit 4. Raman spectra and resonance spectroscopy: (15)

Raman Effect and Raman spectroscopy: Classical and Quantum theory of Raman Effect, Rotational and vibrational structure of Raman spectrum - pure rotational Raman spectra of diatomic molecules, vibration rotation Raman spectrum of diatomic molecule, intensity alterations, Application of IR & Raman spectroscopy. Resonance Technique: NMR – nuclear spin magnetic moment, interaction of nuclear magnet with external field. Quantum description of N.M.R., NMR spectrometer, Chemical shift, Spin–spin interaction, Applications of NMR spectroscopy. Quantum mechanical treatment of Electronic spin resonance (ESR) - Nuclear interaction and hyperfine structure -Relaxation effects - Basic principles of spectrographs - Applications of ESR method. Mossbauer spectra and its applications.

Recommended Books:

1) Introduction to Atomic Spectra – White.
2) Introduction to Atomic Spectra –Herberg.
3) Physics of Atoms and Molecules by B H Bransden and C J Jocachin
4) Laser: Theory and Application, K.Thyagarajan and A.K. Ghatak.
5) Lasers and Non-linear Optics, B.B. Laud.

M.Sc-II, SEM. III, PHYSICS (Solid State)

SCT– 3.1 (SS): ADVANCED CONDENSED MATTER PHYSICS
Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Energy bands in solids: (15)

The basic Hamiltonian in solid, Reduction to one electron problem for determining bands in solids (single particle approximation) - variational principle, Hartree approximation,Hartee-Fock approximation, Density functional approximation-Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond;

Practical DFT in a many body calculation and its reliability.

Unit 2. Magnetism: (15)

Origin of magnetism, quantum theory of diamagnetism, Landau diamagnetism, Paramagnetism: Classical and quantum theory, magnetism in rare-earth and iron group atoms, quenching of orbital angular momentum, Van-Vleck Paramagnetism and Pauli Paramagnetism, Ferromagnetism: Cuireweiss Law, temperature dependence of magnetization, Heisenberg exchange interaction, Ferromagnetic domains, Magnetic domains – exchange energy, magnetostatic energy, wall energy, magnetostrictive energy,Neel and Bloch wall, the Bloch T3/2 law, Neel model of antiferromagnetism and ferrimagnetism. Magnetic anisotropy and magnetostatic interactions- Direct, exchange, indirect exchange and itinerant exchange,(double exchange and RKKY interactions). spin waves in ferromagnets - magnons, Spin waves in lattices –ferri and antiferromagnetism, Measurement of magnon spectrum. Magnetic resonance and crystal field theory, Jahn-Teller effect; Hund's rule and rare earth ions in solids. Pinning effects, The Kondo effect, spin glass, solitons, Magneto resistance – spin valves and spin switchs, giant magneto resistance (GMR),spintronics.

Unit 3. Dielectrics and Ionics: (15)

Diaelectric properties in solid – polarization, electrical conduction, dielectric loss,breakdown of dialectics, nonlinear dielectrics – ferroelectrics, junction capacitor, piezoelectric, electrets ,impedance spectroscopy, complex dielectrics, eclectic modulus. Ionic conduction in solid: defect in solid, conduction mechanism, Nernst Einstein equation, cataonic, protonic and anionic conductor, temperature and frequency dependent of conductivity, hopping mechanism, universal power law (Jonscher's Power Law)oxygen ion conductor, solid electrolyte, fuel cell, SOFC.

Unit 4. Polymers, Composites and Soft matters: (15)

Polymer and their classification, Molecular weight, degree of polymerization, techniques of polymerization, crystallinity of polymers, applications of polymers. Polymer electrolyte, Conducting polymers- concept of solitons, polarons, biolarons, Doping in conducting polymers,

Common conducting polymers, Properties and applications of conducting polymers: PLED, sensors actuators.Composite Materials- various types of composites, microcomposites and mactrocomposites, fiber composites, and matrix materials, Different kinds of soft matters, Symmetry and order parameters,Dispersion colloids, liquid crystal, biological membranes, macromolecules- DNA condensation, bilayer, Marcelja's molecular field theory mesosphere.

Recommended Books:

1) The Modern Theory of Solids- F.Sitz
2) Solid State Theory-W. Harrison, TMH,
3) Introduction to Solid State Physics by C. Kittel.
4) Solid State Physics – A.J. Dekker.
5) Introduction to Solid State Physics – H.P. Myers.
6) Solid state Physics – N.N. Ashcroft and N.D. Mermin.

M.Sc-II, SEM. III, PHYSICS (Solid State)

SCT– 3.2 (SS): EXPERIMENTAL TECHNIQUE IN PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Electronic instrumentations*:* **(15)**

Measurement system- mechanical and electrical, Transducers and its types, sensors, differential output transducer, LVDT, Hygrometers, Measurement of thermal Conductivity (gas analyzer), Physiological transducers Bio-potential electrodes. Digital and analog measuring instruments

– voltmeter, ammeter, oscilloscope, power meter, LCR meter, instrumentation amplifier, filtering and noise reduction in instruments, shielding and grounding, lock-in detector, box-car integrator, interfacing sensors and data acquisition, Integrated circuits technology – fabrications, Power supplies- primary and secondary cell, regulated power supply, SMPS, UPS, Step down switching regulator, Inverters-voltage driven inversion, current driven inversion.

Unit 2. Lasers and Optoelectronic instrumentation : **(15)**

Lasers: - Temporal and special coherence, Einstein coefficients, The threshold condition, two, three and four level laser systems, Modes of a rectangular cavity and open planar resonator, Quality factor, mode selection, The Ruby laser, The Helium-Neon laser, the carbon dioxide (CO2)laser. Optoelectronic devices : Photoconductivity, LDR, photodiode, phototransistor,solar cell, metal semiconductor detector, LCD, CCD , LED, Laser diode, PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes,. Optical fiber- ray propagation Step –index and graded-index fibers, dispersion and attenuation in fiber optics, Dispersion compensation mechanism, Erbium-doped fiber amplifiers, Optoelectronic modulators.

Unit 3(a). X-ray analysis: **(15)**

Origin of X-rays, X-ray generators. Scattering of X-ray, atomic scattering factor,Diffraction of X-ray, various X-ray diffraction methods, X-ray powder diffraction method -indexing of powder lines, Laue’s method, otational/oscillation method, X-ray diffractormeter, determination of crystal structure and lattice parameter, small angle x-ray diffraction and its applications. XPS, XRF and its applications.

3(b).Low pressure and Low temperature: Production of low pressure -Rotary, oil diffusion, turbo molecular, getter and cryo pumps; gauges – Macleod thermoelectric (thermocouple, thermistor and pirani), penning, hot cathode partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components. Production of Low temperature**:** Gas liquifiers; Cryo -fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

Unit 4. Analytical Instrument:- (15)

Electron Microscopy (SEM,TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy and its applications. FT-IR spectroscopy, Luminescence spectroscopy techniques- Fluorescence spectroscopy, Raman spectroscopy, Thermal analysis using DTA, TGA, DSC; Electronic transport analysis using Current vs Voltage characteristics – two probe and four probe techniques - various types of contacts, Dielectric and impedance spectroscopy, spectrum analyzer,fluorescence and Raman spectrometer, Interferometers for different analytical study.

Recommended Books:

1) Electronic Instrumentation - Kalsi H S
2) X-Ray Crystallography – B.E. Warren.
3) Materials Characterization: Introduction to Microscopic and Spectroscopic Methods,
4) Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar

M. Sc-II, SEM. III, PHYSICS (Solid State)

SCT– 3.3 (SS): PROPERTIES OF SOLIDS
Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit - 1 Optical and Dielectric properties (15)

Maxwell's equations and the dielectric function, Lorentz oscillator, the Local field and the frequency dependence of the dielectric constant, Polarization catastrophe, Ferroelectrics Absorption and Dispersion, Kraemers' Kronig relations and sum rules, single electron excitations and plasmons in simple metals, Reflectivity and photoemission in metals and semiconductors Interband transitions and introduction to excitons, Infrared spectroscopy.

Unit - 2 Transport Properties (15)

Motion of electrons and effective mass, The Boltzmann equation and relaxation time, Electrical conductivity of metals and alloys, Mathiessen's rule, Thermo-electric effects, Wiedmann-Franz Law, Lorentz number, ac conductivity, Galvanomagnetic effects.

Unit - 3 Magnetism and Magnetic materials (15)

Review: Basic concepts and units, basic types of magnetic order Origin of atomic moments, Heisenberg exchange interaction, Localized and itinerant electron magnetism, Stoner criterion for ferromagnetism, Indirect exchange mechanism: superexchange and RKKY.

Magnetic phase transition: Introduction to Ising Model and results based on Mean field theory, Other types of magnetic order: superparamagnetism, helimagnetism, metamagnetism, spinglasses.

Magnetic phenomena: Hysteresis, Magnetostriction, Magnetoresistance, Magnetocaloric and magneto-optic effect.

Magnetic Materials: Soft and hard magnets, permanent magnets, media for magnetic recording.

Unit - 4 Superconductivity (15)

The phenomenon of superconductivity: Perfect conductivity and Meissner effect.

Electrodynamics of superconductivity: London's equations, Thermodynamics of the superconducting phase transition: Free energy, entropy and specific heat jump.

Ginzburg-Landau theory of superconductivity: GL equations, GL parameter and classification into Type I and Type II superconductors, The mixed state of superconductors.

Microscopic theory: The Cooper problem, The BCS Hamiltonian, BCS ground

state
Josephson effect: dc and ac effects, Quantum interference.
Superconducting materials and applications: Conventional and High Tc superconductors, superconducting magnets and transmission lines, SQUIDs.

Assignments: should be based on numerical problems related to the syllabus.

Main References:

1. 1. Solid State Physics, H. Ibach and H. Luth, *Springer(Berlin)* 2003 (IL)
2. Solid State Physics, Neil Ashcroft and David Mermin (AM)
3. Introduction to Solid State Physics (7th/ 8th ed) Charles Kittel (K)
4. Principles of Condensed Matter Physics, Chaikin and Lubensky (CL)

Additional References:

1. Principles of Condensed Matter Physics, Chaikin and Lubensky (CL)
2. Intermediate theory of Solids, Alexander Animalu (AA)
3. Optical Properties of Solids, Frederick Wooten, Ac Press (New York) 1972 (FW)
4. Electrons and Phonons, J M Ziman, Electron transport in metals, J.L. Olsen
5. Physics of Magnetism and Magnetic Materials, K.H.J. Buschow and F.R. de Boer Introduction to Magnetism and Magnetic Materials
6. Magnetism and Magnetic Materials, B. D. Cullity

7 Solid State Magnetism, J. Crangle

8 Magnetism in Solids, D. H. Martin

M.Sc-II, SEM. III, PHYSICS (Solid State)

OET– 3.1 (SS): NANOSCIENCE AND TECHNOLOGY

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Nanoscience and semiconductor nanostructures: (15)

Conceptual development of nanoscience,Nanoscience in nature, Clusters, artificial atomic clusters,– clusters to solids, effect on structures, ionization potential, melting etc. Electronic states in semiconductor, Concepts of 2D nanostructures (quantum wells),1D nanostructures (quantum wires) 0D nanostructures (quantum dots), Quantum mechanical treatment of quantum wells, wires and dots, Variation of electronic structure with size of semiconductor nanostructures,Widening of band gap, Effective mass approximation theory and other models for determination of electronic structures in semiconductor nanostructures, Strong and weak confinement in semiconductor nanostructures. Various classes of semiconductor nanostructures, optical properties of semiconductor nanostructures, Phonons in nanostructures.

Energy at nanoscale: surface energy, surface tension, particle curvature and the Young-Laplace equation, chemical potential, DLVO theory, nucleation, ostwald ripening,sintering

Unit 2.Malterials at nanoscale: (15)

Metallic nanostructures- Surface Plasmons , permittivity and permeability based on Lorentz oscillator model, Properties of metallic nanoparticles, surface plasmon resonance, idea of mie theory, stability of metal nanoparticles,

carbon nanostructures-Carbon nanomaterial, Fullerene, Carbon cluster, Carbon nanotubes, SWCNT, MWCNT, graphine, application of carbon nanotube.

Magnetic nanostructures-magnetism in small and nanoparticles, superparamagnetism, introduction to spintronics,spin valve, magnetic tunnel junction, memory elements.

Unit 3. Synthesis and Analysis of nanomaterials : (15)

Various synthesis process, lithography, Ball milling, Atom manipulation by SPM, Microcontact printing, Ion beam deposition, chemical bath deposition , selfassembled mono layers, Molecular beam epitaxy, chemical vapor deposition (CVD) based techniques,pulsed laser deposition, ion beam assisted techniques including embedded nanoparticles, RF sputtering, Characterization of nanomaterial - X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, Energy dispersive analysis, electron energy loss microscopy, Atomic force microscopy,Magnetic Force Microscopy, Scanning tunneling microscopy, optical and vibrational spectroscopy, Scanning near-field optical microscopy, Raman Spectroscopy.

Unit 4 (a) Quantum Transport in nanostructures: (15)

Ballistic transport, Phase coherence, Aharonv-Bohm effect,quantized conductance, Landauer formula, conductance behavior of quantum point contact, Landauer Buttiker formula for multileads, edge state – quantum Hall effect, single electron transport – coulomb blockage, coulomb diamond, SET, molecular electronics, Kondo effect in nanostructures

(b) Applications of nanomaterials and challenges: Application nanostructured material in electronics,photonics, biotechnology, nano-electromechanical systems, Nanocatalysis, nanocompsties and fibers, challenges of nanotechnology.

Recommended Books:

1) Introduction to Low Dimensional Semiconductors- J.H.Davis, Cambridge Press, 1998.

2) Optical Properties of Semiconductors- U.Woggon, Springer-Verlag, 2000.

3) Hand Book of Nanostructured Materials and Technology- Canham.

M.Sc-II, SEM. III, PHYSICS (Solid State)

OET - 3.2: ENERGY HARVESTING DEVICES
Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit -1: Solar Cells **(15)**

Photovoltaic effect, Solar cell characterization, Types of Solar cells, Solid state solar cells Silicon solar cell, CdTe based solar cells, CdS/Cu_2S solar cells, $CuInSe_2$ based solar cells, Metal-semiconductor solar cells, photoelectrochemical and photo electrolysis cells, Solar cells based on thin film heterojunctions, Ultra thin absorber solar cells, Nanostructured solar cells, Dye sensitised solar cells: basic concepts, working and materials. Organic Solar cells: basic concepts, working and materials.

Unit -2: Super Capacitors **(15)**

Comparison of battery and super capacitors, Super capacitor characterization, Types of super capacitors, double layer and pseudo capacitance, hybrid super capacitors, Recent status of carbon, RuO_2 and polyaniline based super capacitors, different methods for preparation of cathodic and anodic electrode materials, Fabrication of super capacitors with examples, Applications of supercapacitors

Unit -3: Fuel Cells **(15)**

Comparison between fuel cells and batteries, fuel cell characterizations, Types of fuel cells: Metal oxide, proton exchange membrane, Phosphoric acid, Solid oxide fuel cells, working of fuel cells, Materials for fuel cells, applications of fuel cells

Unit -4: Piezoelectrics **(15)**

Piezoelectric Energy Harvesting: Energy harvesting basis, case study

Piezoelectric Materials: Piezoelectric polycrystalline ceramics,Piezoelectric Single Crystal Materials, Piezoelectric and Electrostrictive Polymers, Piezoelectric Thin Films. Piezoelectric transducers, Mechanical energy harvester using Laser Micromachining, Mechanical energy harvester using PlezoelectricFibers, Piezoelectric Microcantilevers, Energy harvesting circuits, Multimadal energy harvesting, Mangetoelectric composites, Introduction to Piezoelectric bulk Power generators, Piezoelectric Micro Power Generators, Conversion efficiency, Power storage circuits

Reference Books

1. Semiconductor Sensors, S M Sze, A Wiley- Interscience Publication, John Wiley and Sons, NY1994
2. Electrochemical Supercapacitors, B E Conway, Kluwer Academic/ Plenum publishers, NY 1999.
3. C. N. R. Rao and Claudy Rayan Serrao, J. Mater. Chem., 2007, 17, 4931–4938
4. Solar Cells by Martin Green.
5. Photoelectrochemical Solar Cells by S. Chandra, Gordon &Breach Science Publisher, UK
6. Energy Harvesting Technologies, ShashankPriya, Daniel J. Inman Springer

M.Sc-II, SEM. IV, PHYSICS (Solid State)
HCT -4.1: SEMICONDUCTOR DEVICES
Choice Based Credit System (CBCS)
(w. e. f. June 2019-2020)

Unit 1: Physics of Semiconductor Devices (15)

Carrier transport phenomena in semiconductor solids: drift and diffusion process, Carrier Diffusion, Diffusion Current Density, total Current Density, Graded Impurity Distribution, transport in crystalline and amorphous semiconductors, Induced Electric Field, The Einstein Relation, Temperature dependence of semiconductor conductivity, Carrier life, Shockley-Read-Hall theory

MIS Structure and MOS FETs

Schottky diode, MIS structures, basic equations in flat band conditions, MIS capacitances, current flow mechanisms in MS junction and MIS junction, depletion and enhancement type MOS FETS, capacitances in MOS FETs, quantitative analysis of I - V characteristics, thresholds in MOSFETS, charge trapping and flat band voltage, study of CMOS devices.

Unit 2: Power Devices (15)

Power diodes, ratings, reverses recovery characteristics, fast recovery diodes, Power transistors, Switching characteristics, construction of SCR, two transistors analogy, I - V characteristics, gate trigger characteristics, turn on and turn - off times, losses, reverse recovery characteristics, SCR ratings, dv/dt and di/dt characteristics, thyrister types, construction and characteristics of DIACs and TRIACs, static induction thyristors, , light activatedthyristors, Gate turn off thyristors (GTO), MOS controlled thyristors, programmable Unijunction transistors, Silicon Unidirectional switch (SUS) , IGBT

Unit 3: Charge Coupled and Transferred Electron Devices (15)

Charge storage, surface potential under depletion, construction of basic two and three phase of CCD, mechanism of charge transfer, Oxide Charges, charge trapping and transfer efficiency, dark current, buried channel CCD, application of CCD, Transferred Electron Effect, NDR (Negative differential resistivity of voltage and current controlled devices), formation of gunn domains, uniform and accumulation layer, operation modes, transistors and quenched diodes, layers and modes of operation, LSA mode of operation, frequency responses and overall device performance of Gunn devices.

Unit 4:Optoelectronic and Advanced Solid State Devices (15)

Light emitting diodes, Performance of LEDs, emission spectra, visible and IR LEDs, semiconductor LASER: p-n junction lasers, heterojunction lasers, materials for semiconductor LASER, threshold current density, effect of temp. Quantum well hetero structures, Detectors:photoconductors, photocurrent gain and detectivity, photodiodetypes : p-n junction, p-i-n, avalanche characteristics, quantum efficiency, response speed, noise and optical absorption coefficient, efficiency, Solar cells – current voltage characteristics.

Reference Book/Text Book:

1. D.A. Roustan: Bipolar Semiconductor Devices.
2. Mauro Zambuto: Semiconductor Devices.
3. D. Nagchoudhari: Semiconductor Devices.
4. Karl Hess: Advanced theory of semiconductors devices.
5. S. M. Sze: Physics of Semiconductor Devices 2nd edition..
6. A Dir - Bar - Lev: Semiconductor and Electronic Devices.
7. M. H. Rashid: Power Electronics.
8. P. C. Sen: Power electronics
9. B. G. Streetman and S. Banergee : Solid state Electronic Devices

M.Sc-II, SEM. IV, PHYSICS (Solid State)

HCT - 4.2: NUCLEAR AND PARTICLE PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1. Properties of Nucleus & Nuclear Forces: (15)

Shape and Size, mass, spin and parity, masses and relative abundances, binding energy & nuclear stability, nuclear compositions, quantum properties of nucleon states, Radioactivity; Laws of radioactivity, radioactive dating, radioactive series, theory of alpha, beta & gamma decays and their properties. Nuclear forces: Properties of nuclear forces, two nucleon systemsdeuteron with potentials, n-p and p-p/n-n interactions at different energies, Yukawa's hypothesis, Meson theory of nuclear force.

Unit 2. **Nuclear models**: (15)

Fermi gas model, liquid drop model and Bethe-Weizsacker formula, their applications;shell model and shell structure , extreme single particle shell model with potentials – square well, harmonic oscillator, spin orbit interaction, Magic numbers, Predictions of the shell model; collective nuclear model;
superconductivity model (ideas only).

Unit 3. Nuclear reactions: (15)

Types of nuclear reactions, conservation laws, Nuclear reaction kinematics, nuclear scattering cross section determinations, compound nucleus disintegration, Breit Wigner dispersion formula (one level), direct reactions, nuclear transmutation reactions, nuclear fission and fusion,

Unit 4. Particle Physics & Cosmic rays: (15)

Broad classification of elementary particles and particle interactions in nature, conservation laws, symmetry classifications of elementary particles- Gell-Mann-Nishijima scheme,CPT conservation, Quark hypothesis & Quantum chromodynamics (ideas only); Cosmic rays: origin of cosmic rays, nature of primary cosmic rays and its energy distribution, its geomagnetic ,latitude effect, east-west asymmetry, origin of secondary rays, collision with electrons,. Particle accelerators and detectors: linear accelerators, cyclotron, synchrotron, colliding beam accelerators (LHC), gas-filled counters, scintillation detectors, semiconductor detectors.

Recommended Books:

1. Atomic and Nuclear Physics: Gopalakrishnan (MacMillan)
2. Concepts of Modern Physics: A.Beiser.
3. Concepts of Nuclear Physics: Bernard L Cohen.
4. Nuclear Physics: D C Tayal.
5. Subatomic Physics, Frauenfelder and Henley. (Prentice-Hall)

M.Sc-II, SEM. IV, PHYSICS (Solid State)

HCT - 4.3: THIN FILM PHYSICS AND TECHNOLOGY

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit - 1 Chemical Methods of Thin films synthesis (15)

Chemical vapor deposition: Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD. Chemical bath deposition: ionic and solubility products, preparation of binary semiconductors, Electrodeposition: Deposition mechanism and preparation of compound thin film Spray pyrolysis: Deposition mechanism and preparation of compound thin Films.Ion-assisted deposition (IAD), Laser ablation, Longmuir Blochet film, Sol-gel film deposition.

Unit -2 Physical Methods of Thin Film Synthesis (15)

. Introduction to Thin Films, Thermal evaporation methods: Resistive heating, Flash evaporation, Laser evaporation, Electron bombardment heating, Arc evaporation, Sputtering process: Glow discharge, DC sputtering, Radio frequency sputtering, Magnetron sputtering, Ion beam sputtering.

Unit -3 Physics of Surfaces, Interfaces and Thin films (15)

Mechanism of thin film formation: Formation stages of thin films, Condensation and nucleation, Thermodynamic theory of nucleation, Growth and coalescence of islands, Influence of various factors on final structure of thin films, Crystallographic structure of thin films. Properties of thin films: Conductivity of metal films, Electrical properties of semiconductor thin films, Transport in dielectric thin films, Dielectric properties of thin films, Optical properties of thin films. Thin films of high temperature superconductors, Diamond like carbon thin films

Unit - 4 Thin films for Devices & other Applications (15)

Dielectric deposition- silicon dioxide, silicon nitride, silicon oxynitride, polysilicon deposition, metallization, electromigration, silicides. Thin film transistors, thin film multilayers, optical filters, mirrors, sensors and detectors.

Main References:

1. LudmilaEckertova, Physics of thin films, 2nd Revised edition, Plenum Press, New York, 1986 (Reprinted 1990),
2. K.L. Chopra, Thin film phenomena, Mc-Graw Hill, New York, 1969.
3. L. C. Feldman and J.W. Mayer, Fundamentals of surface and Thin Films Analysis, North Holland, Amsterdam, 1986.
4. S.M. Sze, Semiconductor Devices-Physics and Technology, John Wiley,1985.

Additional References:

1. R.W. Berry, P.M.Hall and M.T. Harris, Thin film technology, Van Nostrand, New Jersey, 1970, K.L.Chopra and LK.Malhotra (ed),
2. Thin Film Technology and Applications, T.M.H. Publishing Co., New Delhi (1984).

M.Sc-II, SEM. IV, PHYSICS (Solid State)

SCT - 4.1: MATERIALS CHARACTERIZATION TECHNIQUES

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1: Microscopic Techniques I (15)

Optical Microscopy and limitations: Principle of Diffraction of light, Airy Disc, Resolution and magnification ; Rayleigh Criteria, Numerical aperture, Major lens defects. Different kinds of optical microscopes (Bright field ,Stereo , Phase contrast ,Differential Interference Contrast ,Fluorescence ,Confocal ,Polarizing light microscope)

Electron Microscopy: Limitations of Light microscopy and advantages of electron microscopy. Wavelength of electrons, Theoretical Resolving power, Source of electron emission .Electron Focusing, Effect of magnetic fields, Electrostatic and magnetic focusing , Optical Column, Magnetic lenses.Vacuum requirements. Schematic of complete SEM

Scanning Electron Microscopy(SEM):Interaction of electrons with matter. Secondary electron emission(SEE),Yield of SEE ,Universal yield curve, Beam scanning and Magnification in SEM, Secondary electrons Detector, Back scattered electrons detector.Electronics. Image analysis.Size histogram. Sample preparation .

Unit 2: Microscopic Techniques II (15)

Transmission Electron Microscopy(TEM) :

Principle of operation, Lens systems, Schematic of TEM ,Apertures, Bright Field Image, Dark Field Image ,.Electron Diffraction, Bragg's Condition, Selective Area Electron Diffraction (SEAD), Image analysis. Sample preparation

Scanning Tunneling Microscopy(STM):

Historical perspective, Electron tunneling ,Principle of STM imaging , STM image interpretation ,STM implementation in instrument , Pizoelectric drive, Tip preparation, Vibration isolation, Data acquisition and analysis,Application of STM , high resolution imaging of surfaces, Spectroscopy, Lithography,Currentfluctuation, Limitation of STM and solution,

Atomic Force Microscopy(AFM) :

Priciple and equations of force curves ,Contact and Non contact modes, Amplitude modulation and Frequency modulation ,Forfe versus distance curve,,Experimental details of AFM, Practical applications .

Unit 3: X-Ray Photoelectron Spectroscopy (15)

Definition of surface, Different Probes for Surface-characterization. Necessity of Ultra High Vacuum, Photoelecton Emission, Introduction and Basic Theory , Historical Perspective ,Instrumentation ,Vacuum System. Energy analyzers, X-Ray Source,Electron Energy Analyzer . Sample Selection and Preparation , Sample Charging .X-Ray Beam Effects., Spectral Analysis ,Core Level Splitting .,Linewidths. Elemental Analysis: Qualitative and Quantitative, Secondary Structure, Angle-Resolved XPS, Depth profiling.

Auger Electron Spectroscopy
Basic principle, Auger Transitions, Kinetic Energies of Auger Electrons, Sensitivity of detection, Instrumentation, Electron Energy Analyzers ,Electron Detector, Sample preparation, Data analysis, Qualitative and Quantitative analysis.

Unit 4: Resonance spectroscopy (15)
Nuclear magnetic resonance and Electron Spin Resonance Spectroscopies.
Properties of Nuclear Spins ,Nuclear Spin Interactions in Solids General Structure of the Internal Hamiltonians , Quantum Mechanical Calculations, Quantum Mechanical Description of NMR , The NMR Signal—Zeeman Interaction ,High Resolution Solid State NMR Methods , Dipolar Decoupling ,Magic-Angle Spinning (MAS), Cross-Polarization (CP) The CP-MAS Experiment ,NMR Spectra.
EPR Condition, Continuous Wave-EPR, EPR Lineshape: Relaxation Times, Electron-Nuclear Interactions: Hyperfine Structure

Reference Books:

1) Handbook ofApplied Solid State Spectroscopy, D. R. Vij, Springer
2) Phtoelectron and Auger Spectroscopy,T.A.Carlson, Plenum Press , 1975
3) Practical Guide to Surface Science and Spectroscopy,Yip-WahChung,Academic Press
4) Fundamental of Molecular Spectroscopy, C.N.Banwell,TataMc-Graw Hill.

M.Sc-II, SEM. IV, PHYSICS (Solid State)

SCT - 4.2: PHYSICS OF NANO MATERIALS

Choice Based Credit System (CBCS)

(w. e. f. June 2019-2020)

Unit 1: Introduction (15)

Background of Nanoscience and Nanotechnology, Definition of Nanoscience and Nanotechnology, Possible Applications of Nanotechnology, Top-down and Bottom-up approach (Brief).

Band Structure and Density of States at Nanoscale: Introduction, Energy Bands, Density of States at Low - dimensional Structures, Quantum confinement – semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement, quantum confinement effect, dielectric quantum confinement, effective mass approximation, core-shell quantum dots.

Unit 2: Properties of Nanomaterials (15)

Optical properties: Absorption, transmission, Beer-Lamberts law (derivation), Photoluminscence, Fluorescence, Phosphorescence,Cathodoluminscence, Electroluminescence, Surface Plasmon resonance (SPR), effect of size of nanoparticles (metal, semiconductor) on absorption and SPR spectra.

Electrical transport: Electrical Conduction in Metals, Classical Theory - The Drude Model Quantum Theory - The Free Electron Model Conduction in Insulators/Ionic Crystals, Electron Transport in Semiconductors, Various Conduction Mechanisms in 3D (Bulk), 2D(Thin Film) and Low – dimensional Systems**,** Thermionic Emission Field – enhanced Thermionic Emission (Schottky Effect), Field - assisted Thermionic Emission from Traps (Poole - Frenkel Effect), Hopping Conduction, Polaron Conduction.

Unit 3: Growth Techniques and Characterization Tools of Nanomaterials (20)

Growth techniques: Introduction, Top - down vs. Bottom - up Technique, Lithographic Process and its limitations , Nonlithorgraphic Techniques ,Plasma Arc Discharge Sputtering ,Evaporation, Chemical Vapour Deposition ,Pulsed Laser Deposition ,Molecular Beam Epitaxy, Sol - Gel Technique , Electrodeposition , Different chemical routes, Other Processes.

Characterization Tools of Nanomaterials: Scanning Probe Microscopy (SPM): Introduction, Basic Principles of SPM Techniques, The Details of scanning Tunneling Mocroscope (STM), General Concept and Definite Characteristics of AFM, Scanned - Proximity Probe Microscopes Laser Beam Deflection, AFM Cantilevers ,Piezoceramics, Feedback Loop Alternative Imaging Modes. Electron Microscopy: Introduction, Resolution vs. Magnification Scanning Electron Microscope SEM Techniques, Electron Gun Specimen Interactions Environmental SEM (FESEM), Transmission Electron Microscope, High Resolution TEM Contrast Transfer Function. Near-field scanning optical microscopy (SNOM/NSOM), UV-Vis single and dual beam spectrophotometer, photoluminescence spectrometer, X-ray diffractometer.

Unit 4: Some Special Topics in Nanotechnology (10)

Introduction ,The Era of New Nanostructure of Carbon Buckminsterfullerene, Carbon Nanotubes, Nanodiamond, BN Nanotubes Nanoelectronics ,Single Electron Transistor, Molecular Machine, Nano-biometrics.

Reference Books:

1) **Introduction to Nanoscience and Nanotechnology:** K.K. Chattopadhyay and A.N. Banerjee, PHI Publisher
2) **Nanoscience and Technology:** V. S. Murlidharan, A. Subramanum.
3) **Nanotubes and Nanofibers:**YuryGogotsi
4) **A Handbook of Nanotechnology :** A. G. Brecket
5) **Instrumentations and Nanostructures:** A. S. Bhatia
6) **Nanotechnology: Nanostructures and Nanomaterials -** M. B. Rao
7) **Nanotechnology-Principles and practices -** S. K. Kulkurni (Capital Publication Company)

M.SC-II, PHYSICS (SOLID STATE)
Choice Based Credit System (CBCS)
(w. e. f. June 2019-2020)
Sem. III
Practical List

HCP 3.1,3.2

1. Calibration of Silicon diode and a copper constantan thermocouple as temperature sensors
2. Thermal diffusivity of Brass
3. Load regulation of constant current source
4. Temperature coefficient of resistance of copper
5. Energy band gap of Silicon using Silicon diode
6. Measurement of self inductance of a coil
7. Measurement of capacitance
8. Growth of single crystal
9. Laue diffraction analysis
10. Thin film deposition by Chemical bath deposition
11. Case Study of SEM micrograph
12. Case Study of NMR pattern
13. Case Study of Raman Spectra
14. Case Study of IR Spectra
15. Case Study of FESEM Spectra
16. Study of material data sheet

SCP 3.1

1. Passive filters
2. AC Bridges (Maxwell, DeSauty, Maxwell-Wein)
3. Dielectric constant of non-polar liquid
4. Dipole moment of an organic molecule, acetone
5. Biprism
6. Thin film deposition by Electrodeposition method
7. Thin film deposition by SILAR method
8. Thickness measurement of thin film

OEP 3.1/3.2

1. Measurement of thermal relaxation time constant of a serial light bulb
2. Mutual inductance with a lock-in amplifier
3. Measurement of low resistance
4. Constant deviation spectrometer
5. Fiber optic communication
6. Michelson's interferometer
7. Curve fitting for given data using Origin
8. To plot XRD of given data using Origin

SEM-IV- MP 4.3-
Major Project